A Dissertation on

EFFECT OF IMMEDIATE HAEMODYNAMIC CHANGES OF KAPALBHATI ON HEALTHY VOLUNTEERS

Submitted by

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DOCTOR OF MEDICINE

BRANCH - II: YOGA

DEPARTMENT OF YOGA

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Dear Dr. M. MALATHYI,

The Institutional Ethics Committee of Government Yoga and Naturopathy Medical College, reviewed and discussed your application for approval of the proposal entitled "EFFECT OF IMMEDIATE HAEMODYNAMIC CHANGES OF KAPALBHATI ON HEALTHY VOLUNTEERS" No. *5052016*

The following members of Ethics Committee were present in the meeting held on 17/05/2016 conducted at Government Yoga and Naturopathy Medical College, Chennai.

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11. Mr. B. Vanakkam Varadharajan, P.R.O., M.T.C. (Retd), Ch-95 -- Social Activist

We approve the proposal to be conducted in its presented form

Sd / Chairman & Other Members

The Institutional Ethics Committee expects to be informed about the progress of the study, and SAE occurring in the course of the study, any changes in the protocol and patient's information / informed consent and asks to be provided a copy of the final report.

Member Secretary, Ethics Committee

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INTRODUCTION

INTRODUCTION

Yoga is the science of right living and, as such, is intended to be incorporated in daily life. It works on all aspects of the person: the physical, vital, mental, emotional, psychic and spiritual.[1]The word Yoga is derived from the Sanskrit word 'Yuj' which essentially means to "join" or "unite". The union referred here is that of

The individual- self uniting with Cosmic Consciousness or the Universal Spirit.[2] Uniting mind and body is yoga. In fact yoga means the union of prana and mind ewith the Self.[3]

Yoga is a right way of life, is characterized by balance in all the aspects, health, harmony and bliss. It gives comfort to the restless mind. Yoga is used for developing memory, intelligence and creativity.[4]Practicing yoga enables the practitioner to get radiant physical health, undisturbed mind, spiritual uplift, and harmony for social wellbeing.[5]

Yoga is one of the six orthodox systems of Indian philosophy. Sage Pathanjali collated, co-ordinated and systemized the yoga in his classical work, the Yoga Sutras, which consists of 185 terse aphorisms.[6]

Sage Patanjali's treatise on raja yoga, the Yoga Sutras, codified the first definitive, unified and comprehensive system of yoga. Often called the eight-fold path is "Ashtanga yoga", it is comprised of yama, self-restraints, niyama, self-observances, asana, pranayama, pratyahara, disassociation of consciousness from the outside

environment, dharana, concentration, dhyana, meditation and samadhi, identification with pureconsciousness.[7]

Pranayama has been assigned very important role in Ashtanga than the Yoga asanas by Maharishi Patanjali because of its efficacy in keeping sound health.[8].

Pranayama are various voluntary breath control techniques that exert profound physiological effects on pulmonary cardiovascular and mental functions.

Pranayama has variable effect on cardiorespiratory system [9]. Pranayama consists of three phases: "Puraka" (inhalation); "Kumbaka" (retention) and "Rechaka" (exhalation) that can be either rapid or slow.[10] Kapalbhati (KB) pranayama is a fast breathing pranayama. KB is one of the kriya which under the classification of Shatkarmas (cleansing techniques) in Hatha Yoga.[11]

According to Gheranda Samhita there are three forms of KB: vatakrama, vyutkrama, and sheetkrama. Hatha Yoga Pradipika describes only vatakrama.

Vata means 'wind' or 'air'.[12]

Regular practice of pranayama in everyday life improves cardio-vascular and respiratory functions, there by improves autonomic tone from sympathetic to parasympathetic nervous system and also decreases the effect of stress and strain of the body and brings improvement in physical and mental health.[13]

By voluntarily controlling breathing pattern, it is possible to influence ANS functions.[14]

There are few studies which indicates that KB practice decreases sympathetic activity by increasing parasympathetic activity and this decreases Heart rate (HR),Systolic blood pressure (SBP) and diastolic blood pressure (DBP).[15] whereas other studies revealed that fast pranayamas like Kapalabhati and Bhastrika practice alone can increases sympathetic activity,[16,17] thereby, increasing HR, SBP, and DBP. Some other studies have found no effect of fast pranayama after 12 weeks of practice.[18]

To the best of our knowledge after done a review of literature, there is no study to evaluate immediate effect of KB pranayama on hemodynamic changes in HR, SV, CO.

Hence the present study was designed to assess the immediate effect produced in the haemodynamics after the practice of KB and followed by 10 minutes relaxation in Savasana on healthy volunteers.

AIMS

AND

OBJECTIVES

2.0 AIMS AND OBJECTIVES

2.1 AIM:

The aim of this study was to evaluate the effect of immediate haemodynamic changes of kapalabhati pranayama on healthy volunteers.

2.2 OBJECTIVES OF THE STUDY:

To evaluate the effects of kapalabhati pranayama on haemodynamic changes.

Primary variables are

Heart Rate (HR)

Stroke volume (SV)

Cardiac output (CO)

REVIEW

OF

LITERATURE

3.0 REVIEW OF LITERATURE

Breath, the vital force of life, is controlled positively by pranayama to ensure homeostasis, physical and mental wellbeing in humans. Pranayama,is the procedure of expansion of the prana or vital energy, occurs through the practices of prananigraha, or control of the prana.[19]

KAPALBHATI

Kapalbhati is highly energizing abdominal breathing exercise. KB is one of the cleansing procedure of yogic Shat kriyas, this is a cleansing exercise; it purifies the blood, removes toxins from the body, cleans the nasal passages and removes bronchial congestion, increases metabolism. In this KB pranayama, complete awareness is given to exhalation only and hardly any effort is applied to inhale. Inhalation is mild, slow and longer than the exhalation.

Van Lysbeth states that KB influences the circulation of blood within the brain. KB changes the volume of the brain according to the respiratory rhythm and, therefore, it increases the irrigation of the brain matter,[20] it has its influence over every systems of the body.

Cardiovascular functions are controlled and regulated by neural factors as well as others such as temperature, hormones, etc.

Of these, neural factors primarily concern the autonomic nervous system (ANS), which plays a major role in maintaining and regulating cardiac functions, e.g., SBP, DBP, SV and HR.

Imbalances in these indicates cardiovascular disorders such as hypertension, tachycardia, bradycardia, ischemia, infarction, etc.[21]

The divine science of pranayama teaches us how to regulate the cardiovascular changes and also reduce the respiratory and HR, while increasing the quantum of oxygen drawn in and decreasing the outflow of breath. This can be as minimal as two or three cycles per minute after the advanced practices of KB.[21]

CARDIAC CYCLE

The cardiac events that occur from the beginning of one heartbeat to the beginning of the next are called the cardiac cycle.Cardiac cycle includes both mechanical and electrical events that occur from the beginning of one heart beat to the beginning of the next. Each cycle is initiated by spontaneous generation of an action potential in the sinus node. This node is located in the superior lateral wall of the right atrium near the opening of the superior vena cava, and the action potential travels from here rapidly through both atria and then through the A-V bundle into the ventricles by bundle branches and Purkinje fibers.[23]

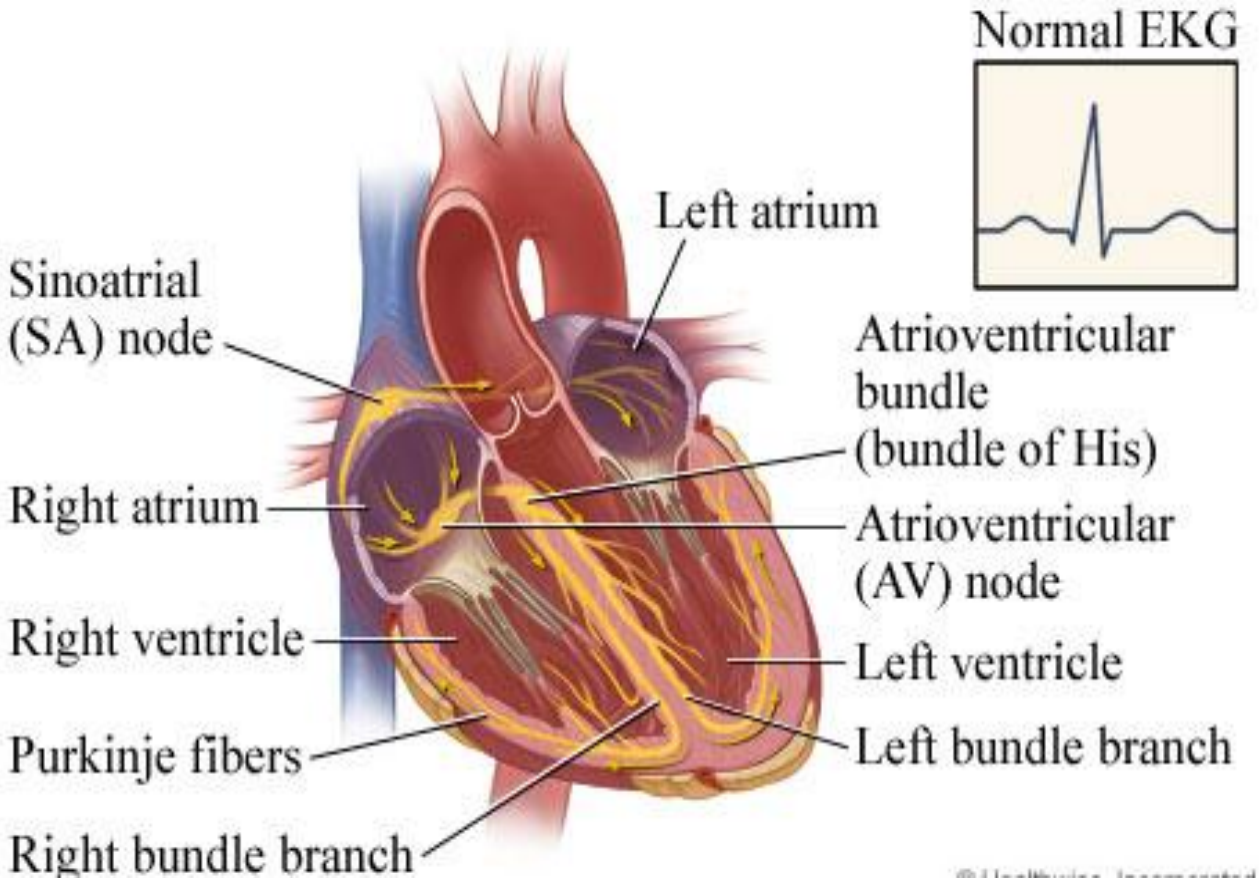


FIGURE 1: Specialized conducting tissues of the heart**.**

TIME TAKEN FOR IMPULSE TO TRAVEL

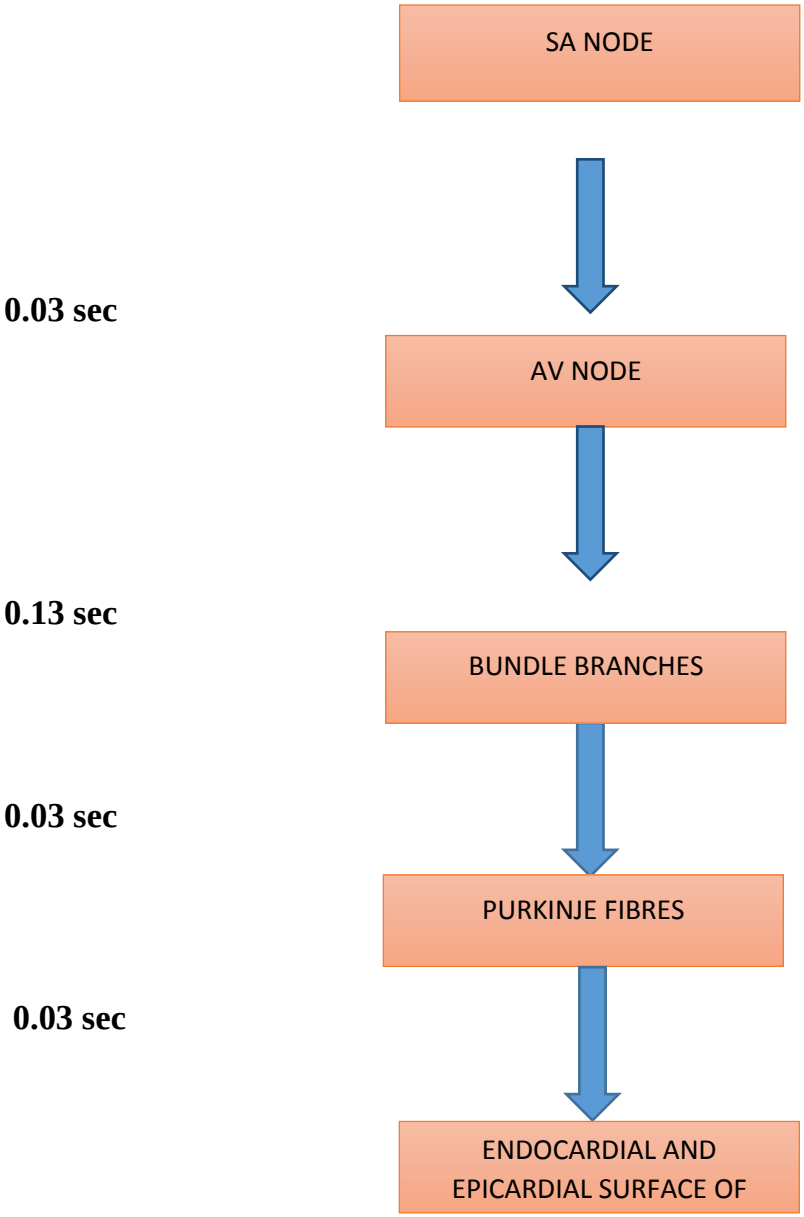


FIGURE 2: Total time required for conduction from the SA node to the endocardial surface

DIASTOLE AND SYSTOLE

The cardiac cycle consists of a period of relaxation called diastole, during which the heart fills with blood, followed by a period of contraction called systole.

Figure 1 shows the different events during the cardiac cycle for the left side of the heart. The top three curves show the pressure changes in the aorta, left ventricle, and left atrium, respectively.[23]

The fourth curved epicts the changes in left ventricular volume, the fifth the electrocardiogram, and the sixth a phonocardiogram, which is a recording of the sounds produced by the heart—mainly by the heart valves—as it pumps.

It is especially important that the reader study in detail this figure and understand the causes of all the events shown.[23]

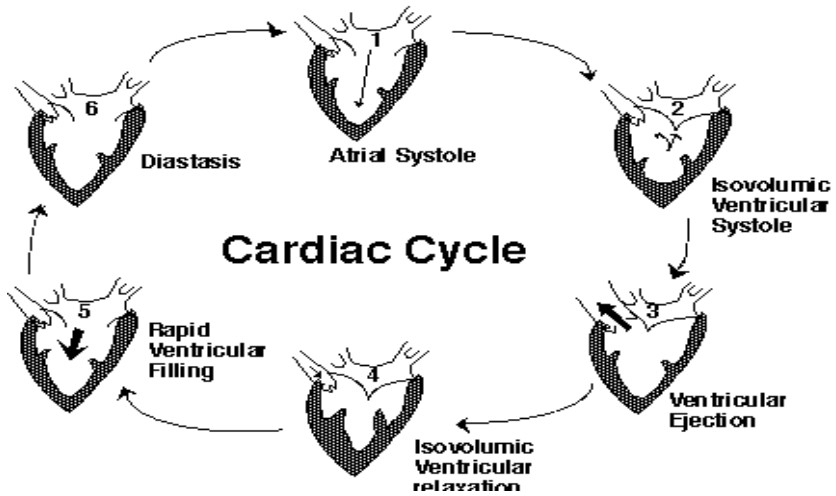


FIGURE: 3 Phases of cardiac cycle

EVENTS OF CARDIAC CYCLE

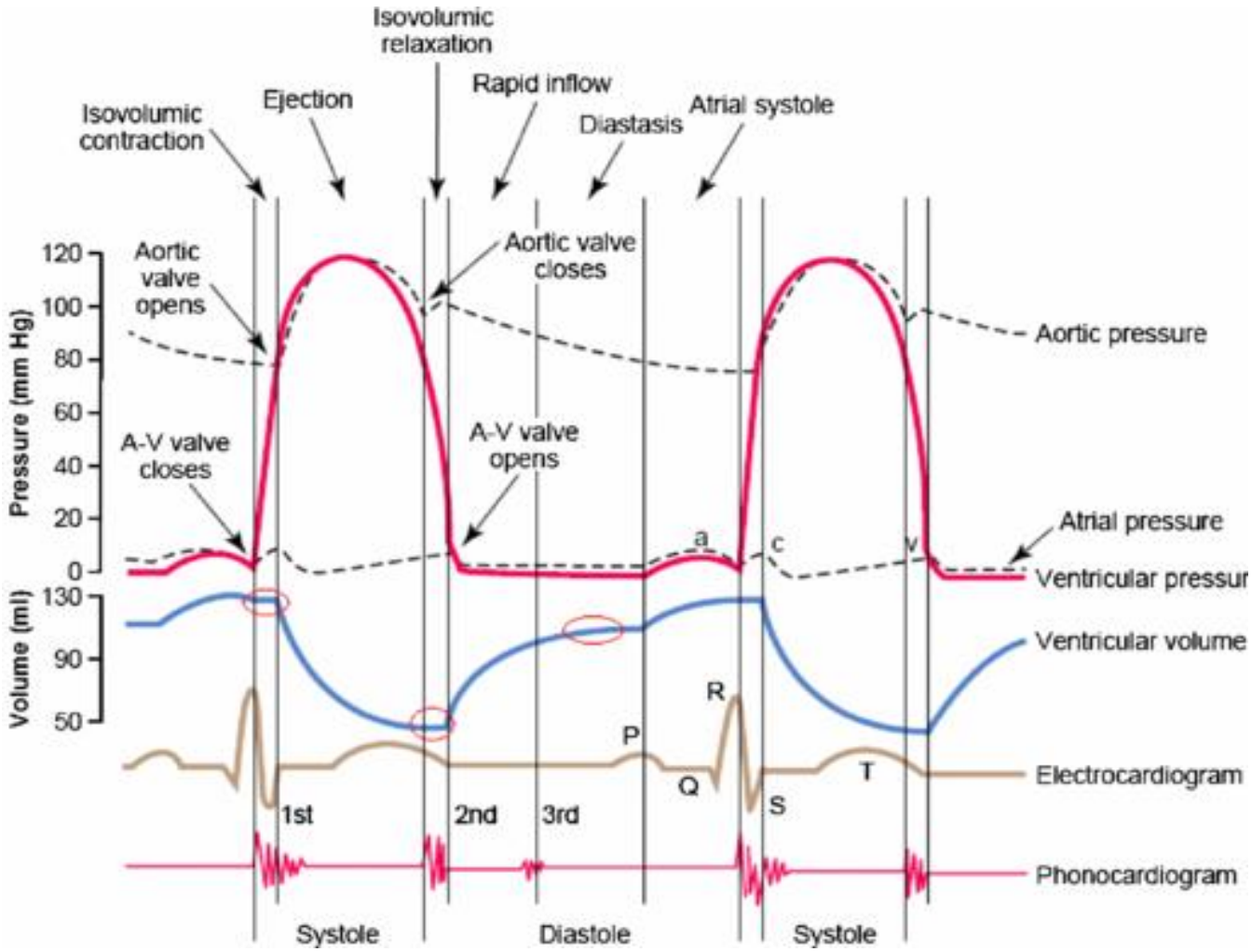


FIGURE-4

Events of the cardiac cycle for left ventricular function, showing changes in left atrial pressure, left ventricular pressure, aortic pressure, ventricular volume, the electrocardiogram, and the phonocardiogram.

END- DIASTOLIC VOLUME,END-SYSTOLIC VOLUME, AND STROKE VOLUME OUTPUT.

Measure	Typical value	Normal range
End - diastolic volume (EDV)	120 ml	65 - 240 ml
End - systolic volume (ESV)	50 ml	16 - 143 ml
Stroke volume (SV)	70 ml	55 - 100 ml
Ejection fraction (E_f)	65 %	55 to 70 %
Heart rate (HR)	75 bpm	60 to 100 bpm
Cardiac output (CO)	5.25 L / minute	4.0 - 8.0 L / min

FIGURE 5: Normal ranges of volumes

END- DIASTOLIC VOLUME

During diastole, normal filling of the ventricles increases the volume of each ventricle to about 110 to 120 milliliters. This volume is called the end-diastolic volume.[23]

STROKE VOLUME

Then, as the ventricles empty during systole, the volume decreases about 70 milliliters, which is called the stroke volume output.

END-SYSTOLIC VOLUME

The remaining volume in each ventricle, about 40 to 50 milliliters, is called the end-systolic volume.

EJECTION FRACTION

The fraction of the end-diastolic volume that is ejected is called the ejection fraction—usually equal to about 60 percent.[15]

HEART RATE

Heart Rate is number of beats per minute, typically 70 to 80 beats/min in young adults but higher in children and elderly.[24]

TACHYCARDIA

The term "tachycardia" means fast HR, usually defined in an adult person as faster than 100 beats per minute.

An electrocardiogram recorded from a patient with tachycardia is shown in Figure 2, is about 150 per minute instead of the normal 72 per minute.

THE GENERAL CAUSES OF TACHYCARDIA INCLUDE

- Increased body temperature,
- Stimulation of the heart by the sympathetic nerves, or toxic conditions of the heart.[23]

FIGURE 6 Sinus tachycardia lead- 1

BRADYCARDIA

The term “bradycardia” means a slow HR, usually defined as fewer than 60 Beats per minute.[23]

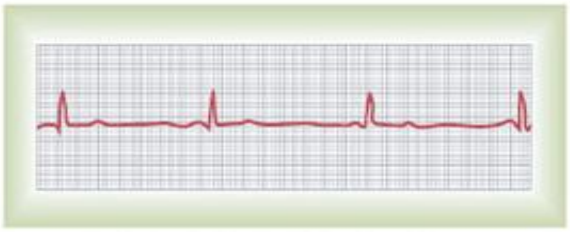


FIGURE 7 Sinusbradycardia lead-111

VAGAL STIMULATION AS A CAUSE OF BRADYCARDIA

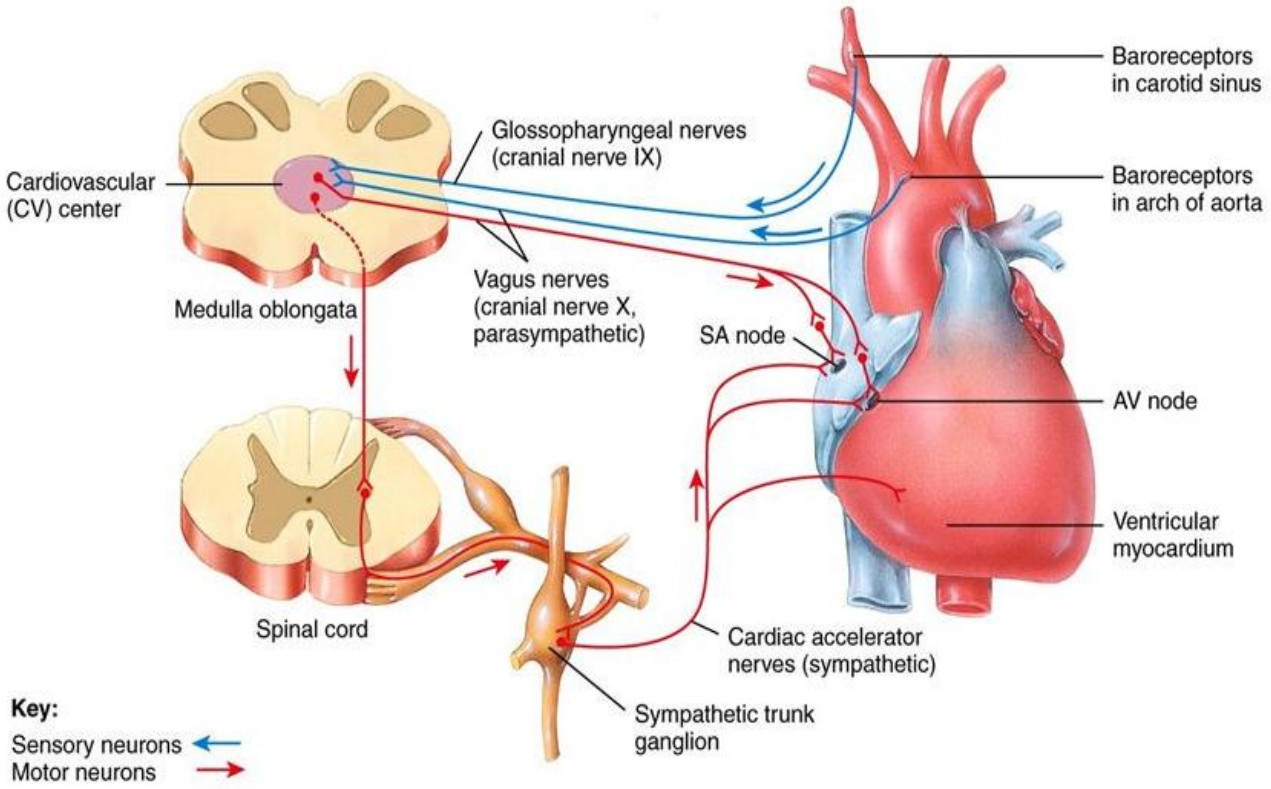


FIGURE 8 Bradycardia by vagal stimulation

Any circulatory reflex that stimulates the vagus nerves causes release of acetylcholine at the vagal endings in the heart, thus giving a parasympathetic effect.[25]

STROKE VOLUME

Stroke volume is the amount of blood that leaves the heart with each beat or ventricular contraction. Normal Adult 70 ml / beat. Stroke volume = end-diastolic volume – end-systolic volume.[26]

EJECTION FRACTION

The fraction of the end-diastolic volume that is ejected is called the ejection fraction—usually equal to about 60 per cent.[23]

INCREASE IN STROKE VOLUME

When the heart contracts strongly, the end-systolic volume can be decreased to as little as 10 to 20 milliliters. Conversely, when large amounts of blood flow into the ventricles during diastole, the ventricular end-diastolic volumes can become as great as 150 to 180milliliters in the healthy heart.

By both increasing the end-diastolic volume and decreasing the end-systolic volume, the stroke volume output can be increased to more than double normal.[23]

CARDIAC OUT PUT

Cardiac output is the amount of blood the heart pumps in 1 minute, and it is dependent on the HR, contractility, preload, and after load.

Cardiac output, expressed in liters/minute, is the amount of blood the heart pumps in 1 minute. Cardiac output is logically equal to the product of the stroke volume and the number of beats per minute (HR).[26]

Cardiac output is the volume of blood pumped by heart each minute. It is product of HR and stroke volume and averages about 5.25 L/min.

Cardiac output is HR x stroke volume.[26]

VARIATION IN CARDIAC OUTPPUT

PHYSIOLOGICAL CAUSES OF VARIATIONS IN CARDIAC OUTPUT

- Age: Because of less body surface
- Sex: Since the body surface area is less in females than males.
- Diurnal variation: In the early morning cardiac output is low which increases in the day time.
- Environmental temperature: A high environmental temperature is associated with an increase in the cardiac output.
- Anxiety and excitement are reported to increase the CO by 50-100%[26].

	Condition or Factor
No change	Sleep Moderate changes in environmental temperature
Increase	Anxiety and excitement (50 – 100 %) Eating (30 %) Exercise (up to 700 %) High environmental temperature Pregnancy (Later months) Epinephrine High Altitude due to hypoxia Day time according to metabolic activity
Decrease	Sitting or standing from lying position (20 – 30 %)

FIGURE 9 Physiological causes of variation in cardiac output[27]

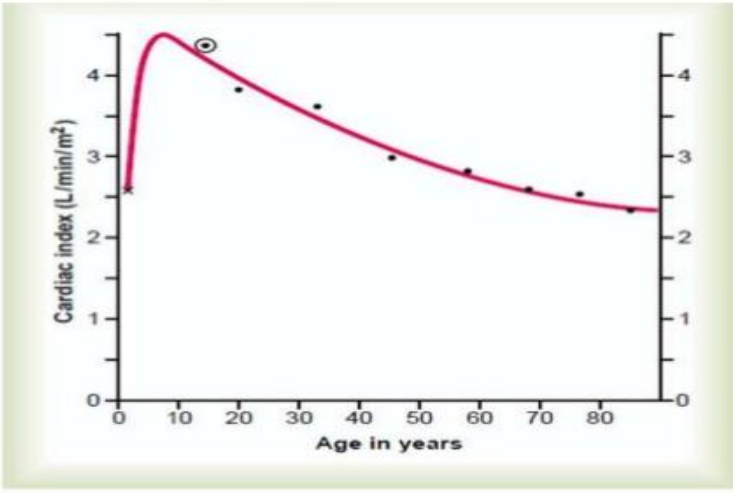


FIGURE 10 Cardiac index for the human being at different ages[26]

- Eating is associated with an increase in cardiac output approximately by 30%
- Exercise may increase the cardiac output up to 700% depending upon the vigorousness of exercise.
- Pregnancy. An increase in cardiac output to the tune of 45-60% is reported during the later months of the pregnancy.
- High altitude. The cardiac output is increased at a high altitude due to release of adrenaline as a consequence to hypoxia.
- Posture change. Sitting or standing from lying down position may decrease the cardiac output by 20-30% because of pooling of blood in the lower limb.[27]

FACTORS REGULATING CARDIAC OUTPUT

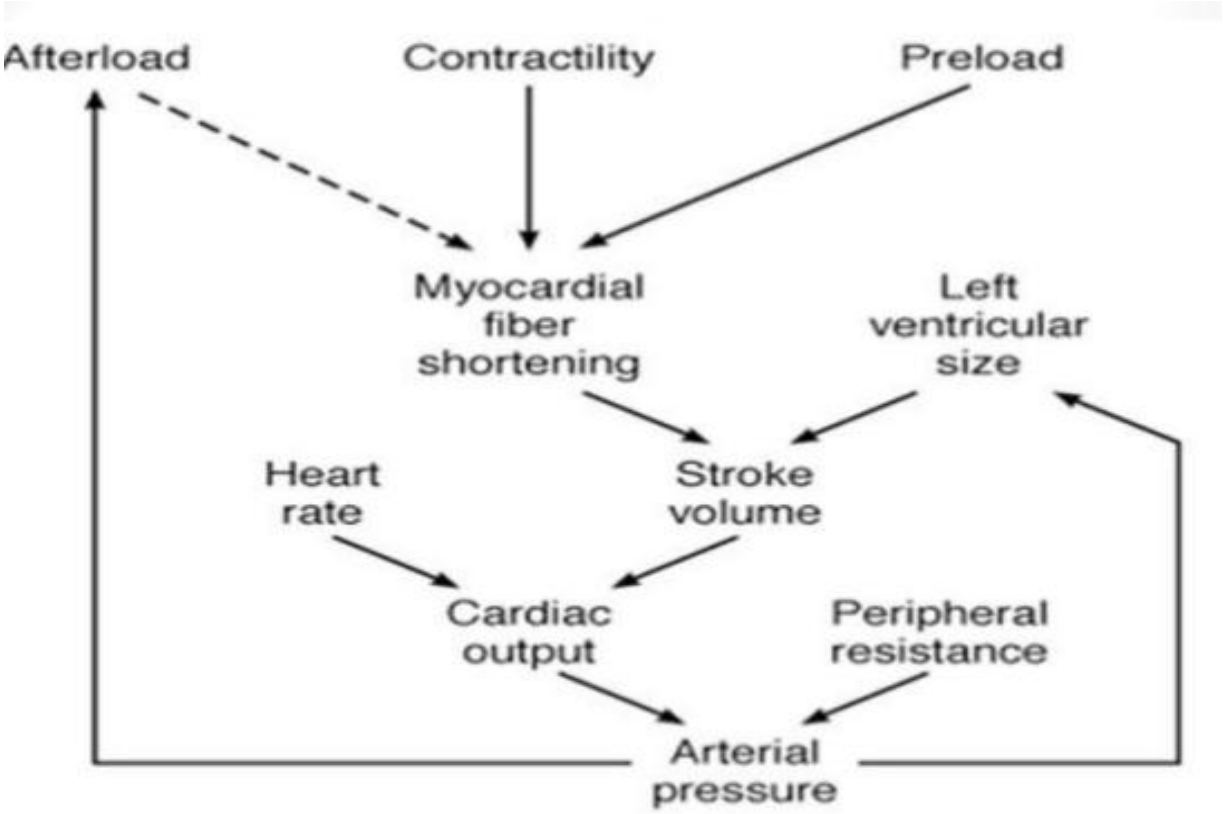


FIGURE 11 Factors regulating cardiac output

HIGH CARDIAC OUTPUT CAUSED BY REDUCED TOTAL PERIPHERAL RESISTANCE

Reduced peripheral resistance increases venous return which will increases HR and stroke volume there by increasing the cardiac output.

REDUCED PERIPHERAL RESISTANCE REGULATING CARDIAC OUTPUT

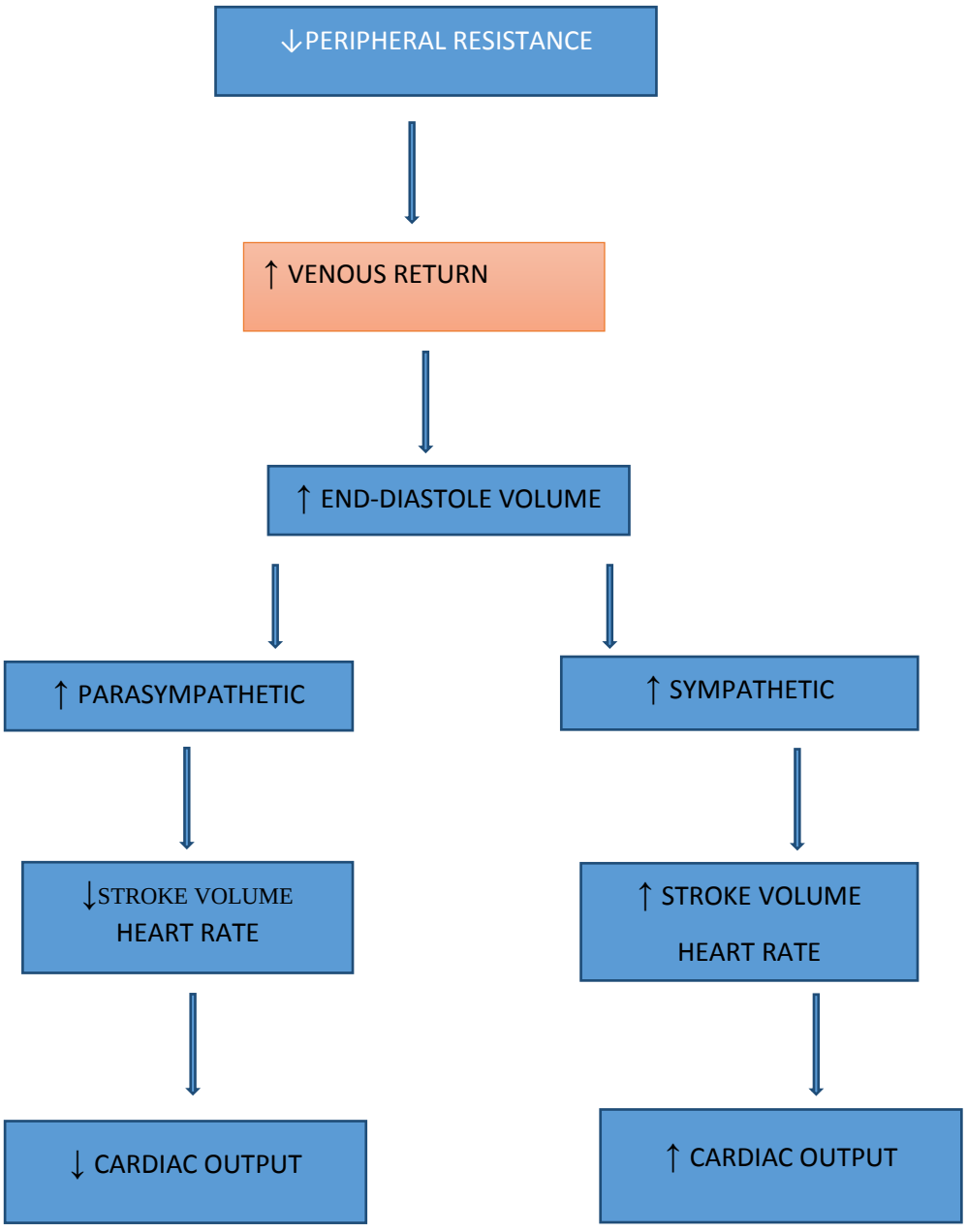


FIGURE 12 Venous return and cardiac output

CONTROL OF CARDIAC OUTPUT BY VENOUS RETURN—ROLE OF THE FRANK-STARLING

MECHANISM OF THE HEART

The peripheral factors are more important than the heart itself in controlling cardiac

Output, the heart has a built-in mechanism that normally allows it to pump automatically whatever amount of blood that flows into the right atrium from the veins. This mechanism, called the Frank-Starling law.

This law states that when increased quantities of blood flow into the heart, the increased blood stretches the walls of the heart chambers. As a result of the stretch, the cardiac muscle contracts with increased force, and this empties the extra blood that has entered from the systemic circulation.[26]

PATHOLOGICALLY HIGH AND PATHOLOGICALLY LOW CARDIAC OUTPUTS

INCREASED CARDIAC OUTPUT BY REDUCED PERIPHERAL RESISTANCE

1. Beriberi

2. Arteriovenous fistula (shunt)

3. Hyperthyroidism

4. Anemia

LOW CARDIAC OUT PUT

(1) Abnormalities that cause the pumping effectiveness of the heart to fall too low

(2) Cause of venous return to fall too low.[26]

DECREASED CARDIAC OUTPUT

CAUSED BY CARDIAC FACTORS

- severe coronary blood vessel blockage
- myocardial infarction,
- severe valvular heart disease,
- myocarditis,
- cardiac tamponade,
- cardiac metabolic derangements.[26]

DECREASED CARDIAC OUTPUT BY DECREASED VENOUS RETURN

1. Decreased blood volume

2. Acute venous dilation.

3. Obstruction of the large veins.

4. Decreased tissue mass.[26]

Physiological activities of the cardiovascular system are under the control of the ANS.[28]

VASOMOTOR CENTER IN THE BRAIN AND ITS CONTROL OF THE VASOCONSTRICTOR SYSTEM.

VASOMOTOR CENTRE:

It is the centre which regulates the heart.

SITUATION:

It is bilaterally situated in the reticular formation of medulla oblongata and lower pons.

AREA:

1. Vasoconstrictor area

2. Vasodilator area

3. Sensory area.[29]

VASOMOTOR CENTER IN THE BRAIN AND ITS CONTROL OF THE VASO CONSTRICTOR SYSTEM

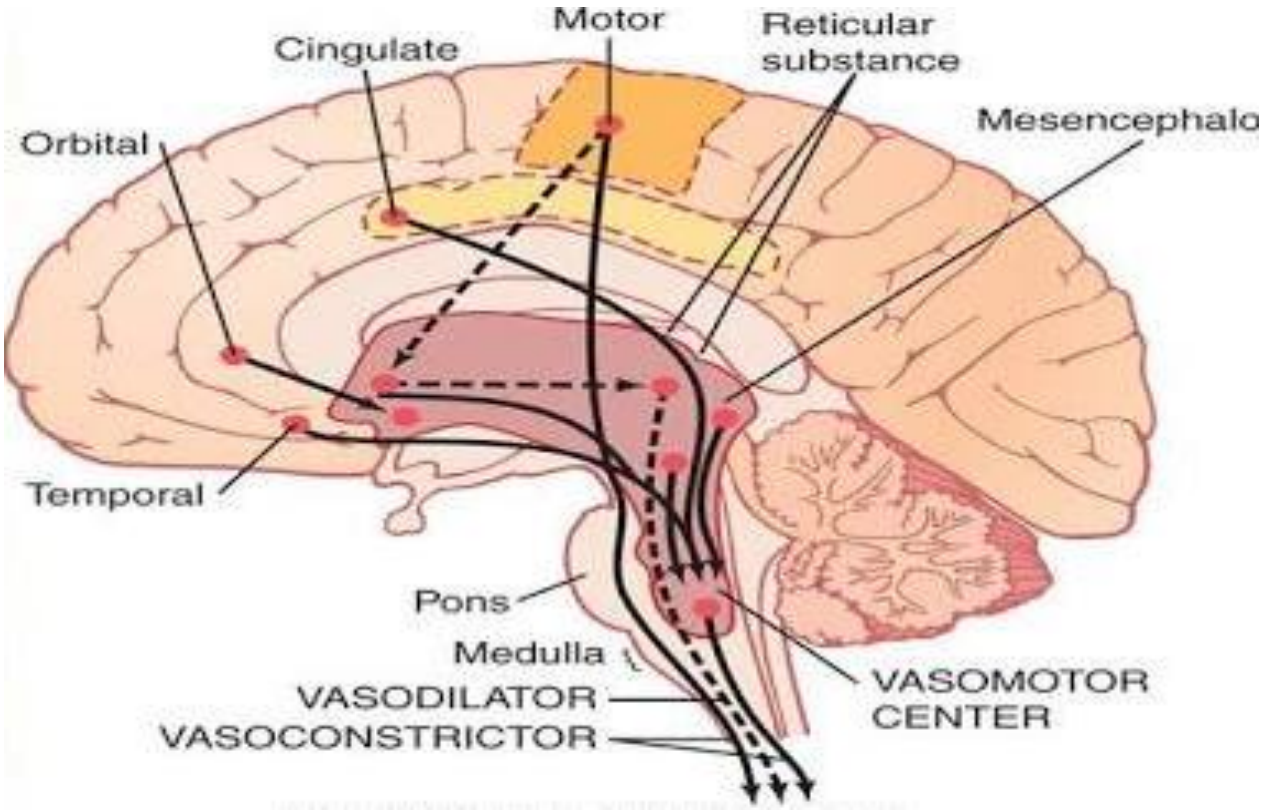


FIGURE 13 Areas of the brain in the nervous regulation of the circulation

CARDIAC SYMPATHETIC AND PARASYMPATHETIC NERVES

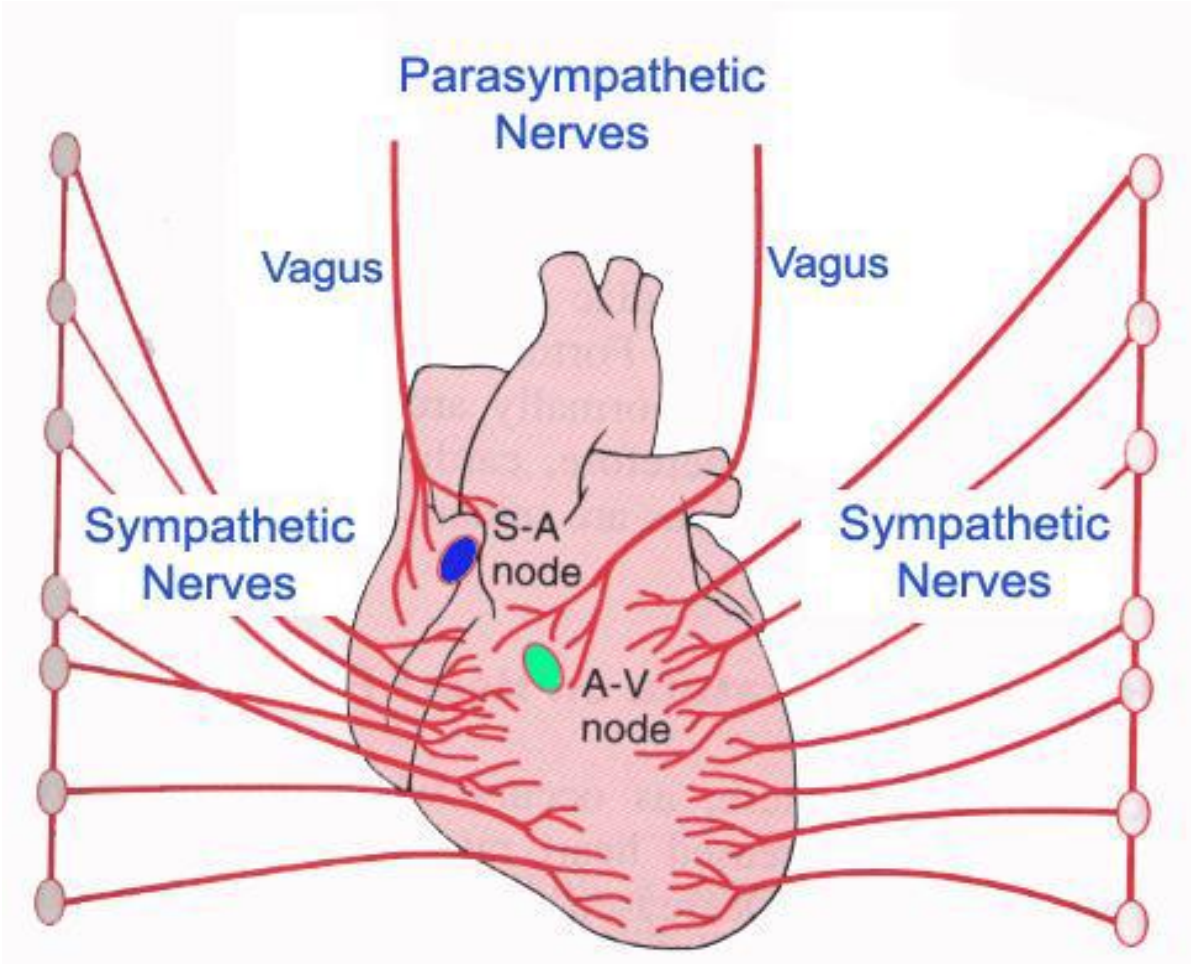


FIGURE 14 The vagus nerves to the heart are parasympathetic nerves.

ANATOMY OF SYMPATHETIC NERVOUS CONTROL OF THE

SHOWN BY THE RED DASHED LINE IS A VAGUS NERVE THAT

CARRIES PARASYMPATHETICSIGNALS TO THE HEART

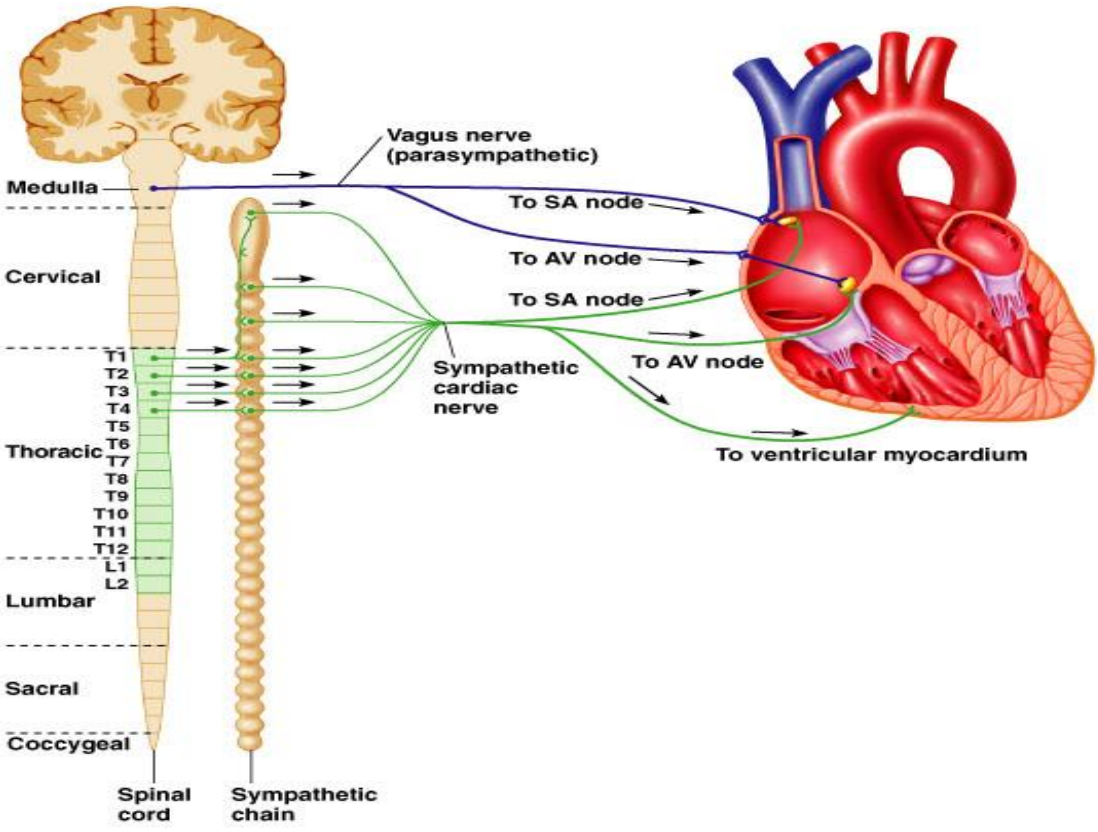


FIGURE 15 Anatomy of sympathetic nervous control of the circulation

REGULATION OF HEART PUMPING

VASOCONSTRICTOR AREA

It is situated in reticular formation of medulla in the floor of fourth Ventricle.

"Cardiac Accelerator Centre"

↓

Increases the Heart Rate

↓

Through activation of Sympathetic Nerve fibers.[29]

VASODILATOR AREA

"Cardiac Depressor Centre"

↓

Decreases the Heart Rate

↓

Through activation of Parasympathetic Nerve fibers (Vagus Nerve)

SENSORY AREA

It controls the vasoconstrictor and vasodilator area.[29]

MOTOR EFFERENT FIBERS TO HEART:

Vagus Nerve (Parasympathetic Nerve)

↓

Cardio inhibitory in function.[29]

SENSORY AFFERENT NERVE FIBERS FROM HEART

Sympathetic Nerve

↓

Cardio acceleratory in function[29]

BARORECEPTOR REFLEXES

Basically, this reflex is initiated by stretch receptors, called either baroreceptors or pressoreceptors.locatedat specific points in the walls of several large systemic arteries. Baroreceptors are located in the wall of almost every large artery of the thoracic and neck regions baroreceptors are extremely present in

(1) The wall of each internal carotid artery slightly above the carotid bifurcation, an area known as the carotid sinus, and

(2)The wall of the aortic arch.[29]

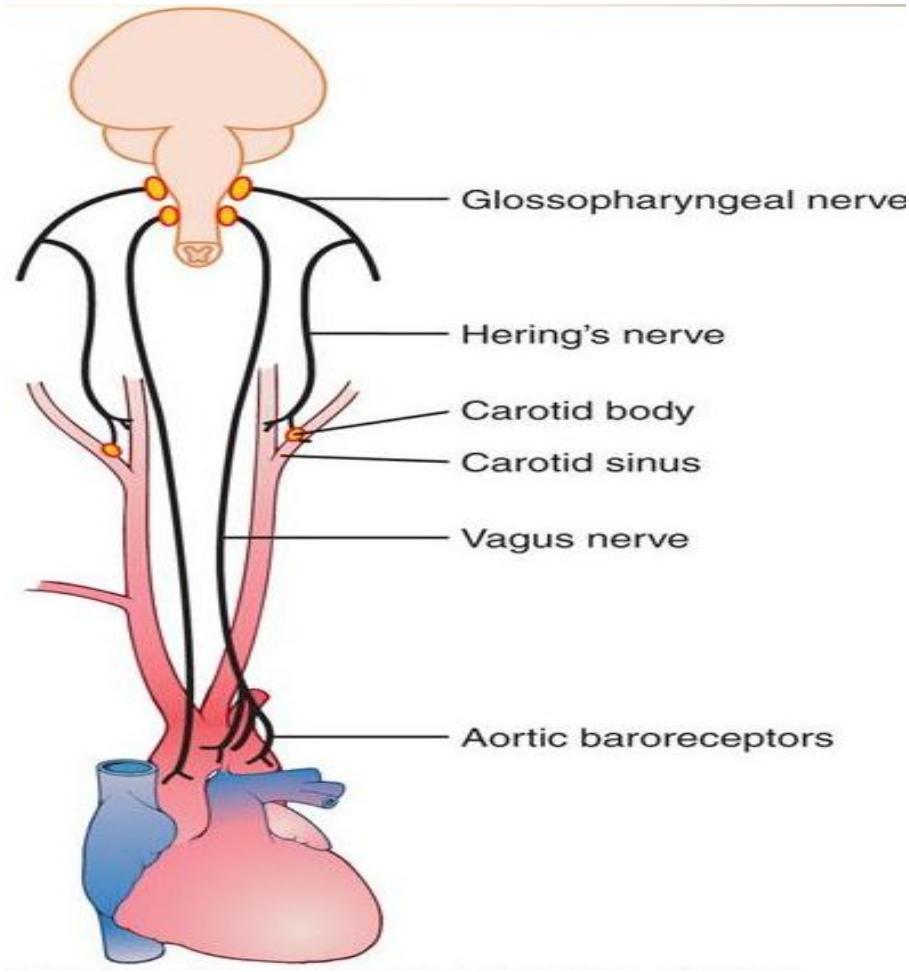


FIGURE-16 The baroreceptor system for controlling arterial pressure

PHYSIOLOGYOF THE BARORECEPTORS

EFFECT OF BARAORECEPTORS

Larger arteries get streatched

↓

Baroreceptors get stimulated

↓

Baroreceptors entered the medulla(Tractussolitorius)

↓

Secondary signals inhibit the vasoconstrictor center of themedulla and excite the parasympathetic center

↙ ↘

Effect

Vasodilation of veins and arterioles

Decrease Heart rate and strength ofheart contraction

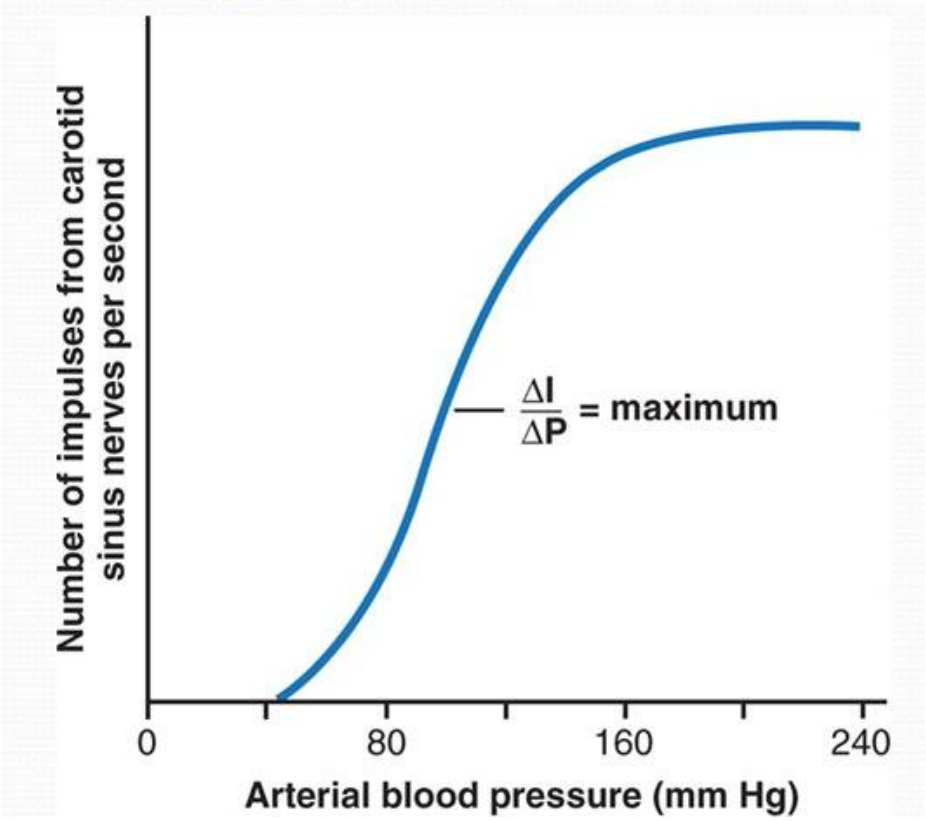
↘ ↙

Therefore excitation of baroreceptors by pressure in thearteries reflexly causes decrease in heart rate and cardiac output.[29]

RESPONSE OF THE BARORECEPTORS TO PRESSURE.

Figure–shows the effect of different arterial pressure levels on the rate of impulse transmission in a Hering's carotid sinus nerve.

Response to Arterial Pressure



FIGURE–17 Activation of the baroreceptors at different levels of arterialpressure.[29]

CHEMORECEPTORS IN CARDIOVASCULAR REGULATION

CHEMORECEPTORS :

Chemoreceptors are chemo sensitive cells ,which are responsible for

- Oxygen lack (decreased Partial pressure of Oxygen)
- Carbon dioxide excess
- Excess of Hydrogen ions.[27]

CHEMORECEPTORS

CHEMOSENSITIVE CELLS THA RESPOND TO CHANGE IN pCO2 AND pO2 AND pH LEVELS (Hydrogen ion)

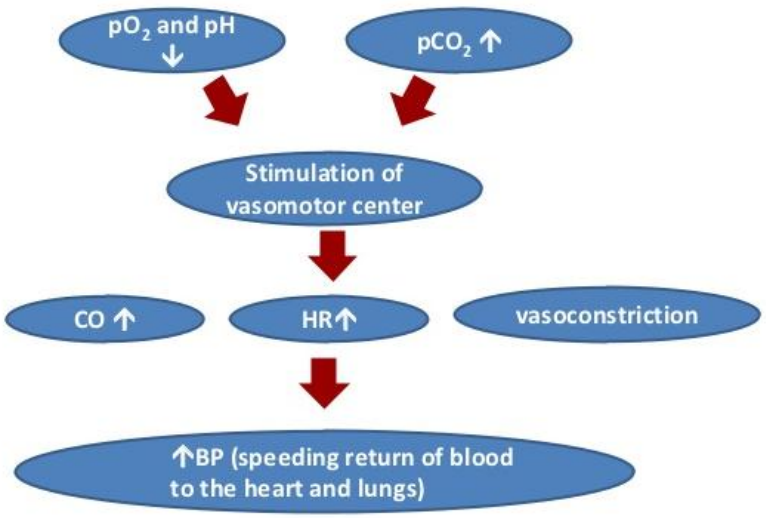


FIGURE-18 Chemosensitive cell responds

HAEMODYNAMICS

Hemodynamics, which refers to the study of blood flow in various segments of the vascular system. Hemodynamics can be discussed under following headings,

- General principles governing (factors affecting) blood flow,
- Types blood flow,
- Measurements of blood flow,
- Distribution of blood flow to various regions of the body and,
- Regulation of blood flow in different situation.[30]

KAPALABHATI(KB)

Pranayama, one of the eight limbs of Ashtanga yoga, generally denotes extension of life; as “prana” means life force and “ayama” means expansion of vital energy.

Pranayama increases life span and maintains health by the practice of prolonging and shortening the breathing cycle.[31]

This is because respiratory impulses, are one of the subtle channels of the autonomic nerve currents and are controlled by pranayama. These pranayama practices can prevent and cure conditions which cause disruption of homeostatic condition of autonomic nervous systems .[32]

Kapalabhati is an one of the important practice of Shatkarma, the yogic system of body cleansing techniques.

In GherendaSamhita it is known as bhalabhati.Bhala and kapal mean the ‘cranium’ or’ fore head’.Bhati is ‘light’ or ‘splendour’, it also means ‘perception and knowledge’.

KB is a pranayama technique which invigorates the entire brain and awakens the dormant centers which are responsible for subtle perception to achieve spiritual enlightment.[33]

It helps to detoxify lungs andrespiratory tracts,improves cardio vascular functions, boosts the supply of oxygen, purifies blood,enhance metabolism and helps to tone up the abdominal muscles there by reduces insulin resistance. It is also helpful in reducing abdominal fat, improvises concentration span.[34]

Bhastrāvallohakārasyarecapūrausasambhramau |

Kapālabhātirvikhyātākaphadoṣaviśoṣanī ||

Ṣatkarmanirgatasthaulyakaphadoṣamalādikaḥ |

Prānayāmamṭataḥkuryādanāyāsenasiddhyati ||

Prānāyāmairevasarvepraśuṣyantimalāiti |

Ācāryānāṃtukeṣāṃcidanyatkarmanasaṃmatam ||

-Hatha Yoga Pradipika (2/35, 36&37)

Meaning: Perform exhalation and inhalation rapidly like bellows (of the blacksmith). This is called Kapalabhati and it destroys all mucous disorders. By the Shatkarma (six

cleansing processes of Hatha yoga) one become free from excess of the Doshas. Then Pranayama is practiced and success is achieved without strain. According to some of the masters of Hatha yoga, pranayama alone removes impurities and therefore they hold pranayama in esteem and not the other techniques.[33]

PHYSIOLOGY OF KAPALBHATI

During normal breathing exhalation is a passive process by which there is an automatic recoiling of the diaphragm forcibly exhaling the air out of the lungs.

In normal breathing the abdominal muscles called external and internal obliques, rectus, andtransversusabdominis, which are not normally used , are the most powerful muscles for forced exhalation.

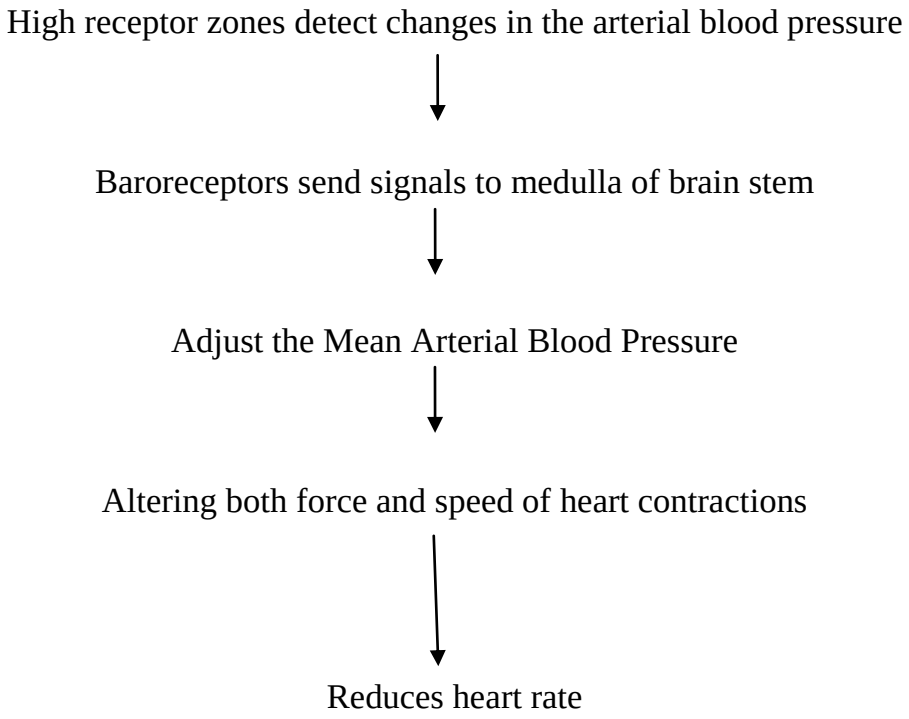
Contraction of these abdominal muscles creates negative pressure on the abdominal organs which then eventually push diaphragm up ending in forcible exhalation. Abdominal breathing increases tidal volume and is known to produce emotional stability in the stressful environments.

This because of elevated parasympatheticdominence over sympathetic activity leading to better oxygenation of brain and heart in spite of low HR.[35]

During the Kapalabhati breathing practice, oxygen consumption rates increases by approximately 1.1–1.8 times.

HR increases during the initial 20-40secs of KB practice, which then reduced gradually to normal.[35]

BARO REFLEXES:



By practicing KB the baroreceptors are stimulated which leads to inhibition of tonic discharge of vasoconstrictor nerves and excitation of vagal innervation of heart and there by produces vasodilatation venodilatationandbradycardia (decreased HR).

TRIGEMINAL CARDIAC REFLEX

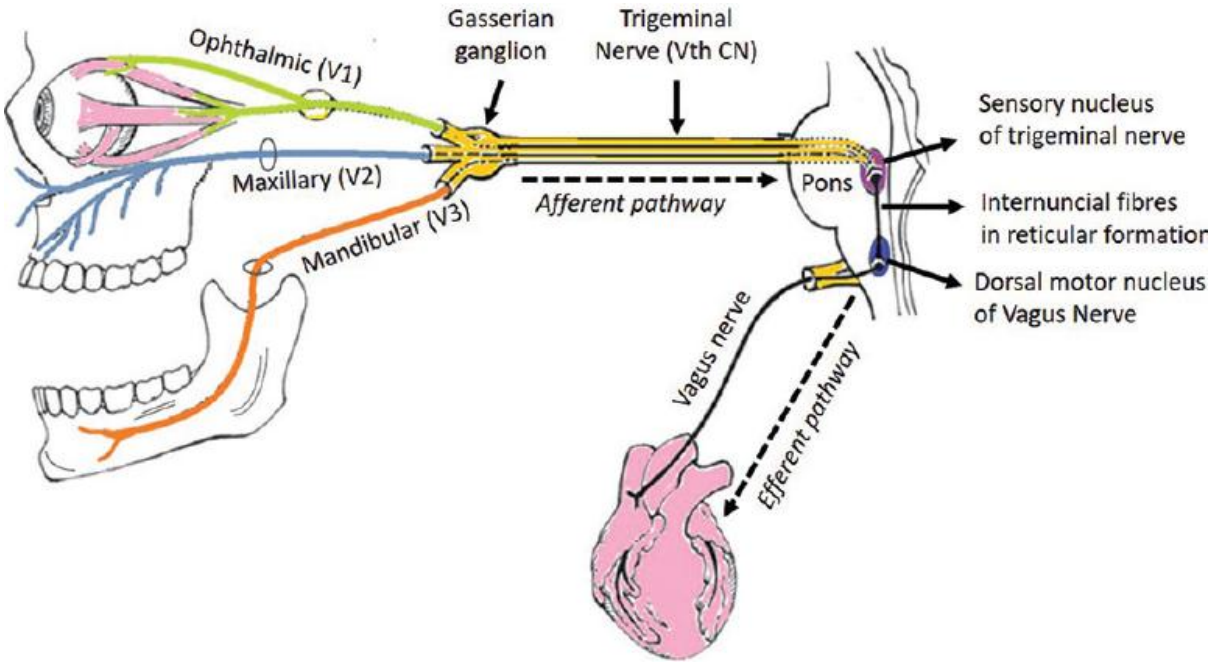
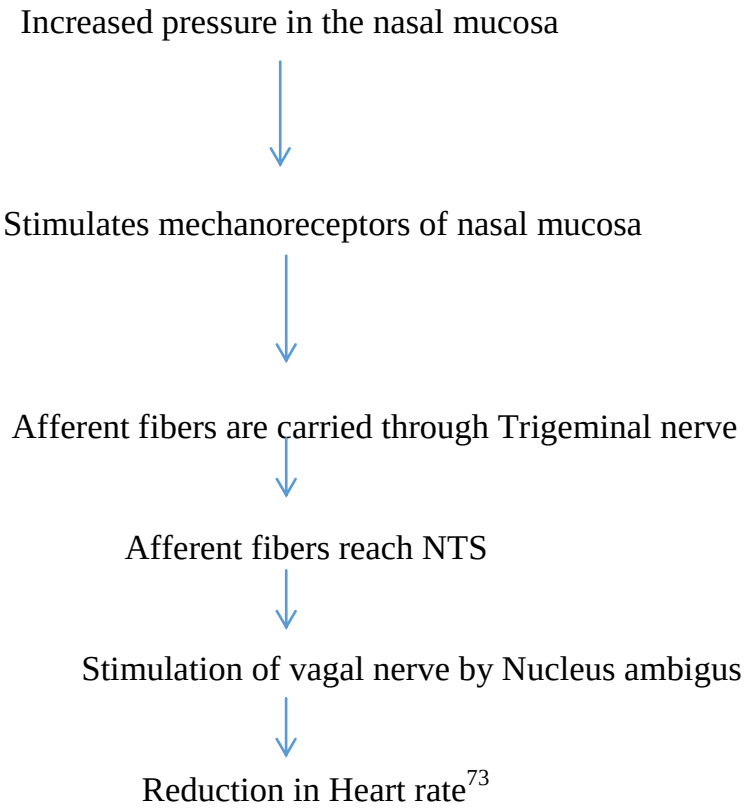


FIGURE 20: Pathway of trigemino cardiac reflex.

The trigerminal cardiac reflex (TCR) is a unique brain stem reflex that manifests as typical haemodynamic perpurbations including sudden lowering of HR, mean arterial blood pressure, cardiac arrhythmias asystole and other autonomic reactions such as apnea and gastric hypermotility.[72]

As activation of baroreceptor afferent fibers projecting to the Nucleus tractus solitaries (NTS) elicits a decrease in HR it is likely that there is a connection between NTS and Nucleas Ambigus (NA).[73]

NASOCARDIAC REFLEX



On the other side, during normal breathing the intrapleural (intrathoracic) pressure at the end of expiration is about -2mmhg.

During inspiration, the intrathoracic pressure becomes more negative due to which the diameter of inferior vena cava is increased and pressure inside it is decreased., and there occurs descend of diaphragm which increases the intra-abdominal pressure.

The decreased pressure inside the Inferior vena cava (IVC) coupled with increased intra-abdominal pressure during inspiration results in the increased flow of blood into the right atrium.

This happens repeatedly during forceful expiration of KB.Hence increased blood in right atrium increases venous return and there by increases the SV.

BENEFITS OF KAPALBHATI

Kapalabhati Pranayama maintains acid–base balance.

Deep inhalation makes the dead space of the lungs active.[36]

Improve blood circulation and glandular secretions.

Kapalabhati practice balances vata (wind), pitta (bile), and kapha (phlegm), thereby creates psychological balance which involves awakening of "Kundalini" power, and improvement in concentration.[37]

There are few studies which indicates that KB practicce decreases sympathetic activity by increasing parasympathetic activity and this decreases Hear trate (HR),Systolic blood pressure(SBP) and diastolic blood pressure(DBP).[15] whereas other studies revealed that fast pranayamas like Kapalabhati and Bhastrika practice alone can increases sympathetic activity,[16,17] thereby, increasing HR(HR), systolic blood pressue(SBP), and Diastolic blood pressure(DBP).

Some other studies have found no effect of fast pranayama after 12 weeks of practice.[18]

To the best of our knowledge, there is no study was conducted to evaluate immediate effect of KB pranayama on haemodynamic (Heartrate,Strokevolume,Cardiac output) changes on healthy volunteers. Hence the present study was designed to assess the immediate effect on haemodynamic changes after the practice of KB on healthy volunteers.

3.1 IMMEDIATE EFFECT OF KAPALBHATI ON CARDIOVASCULAR ENDURANCE

Ganguly et al.,1981 Study done to evaluvate the immediate effect of KB on cardio-respiratory endurance and observed a significant improvement in the cardiovascular endurance after performing one minute of KB as compared to hyperventilation of similar duration.[38]

3.2 KAPALBHATI ON VOLUNTARY HYPERVENTILATION

Karambelkar. et.al. 1982, studied to found the effect of KB on Voluntary Hyperventilation. Even though breathing rate is very high during KB (120/min.) in comparison to voluntary hyperventilation (26/min.); the minute ventilation in the later was found to be twice (31 lit./min.) and the tidal volume was almost ten times than in KB. Oxygen consumption was around 1.5 times more while co2 output was more by 3.5 times and breath-holding time was about twice more in hyperventilation.[39]

3.3 IMMEDIATE EFFECT OF KAPALBHATI ON RESPIRATORY FUNCTION

Gore Gharote. Et.al. 1988, done a study to find "Immediate effect of one minute KB on respiratory function" . Respiratory rate, minute Ventilation and oxygen consumption where significantly increased, and the tidal volume was significantly decreased during the practice of KB for one minute. Oxygen cocumption was reduced than the resting value immediately after the practice of KB.[40]

3.4 KAPALBHATI ON BODY FUNCTIONS

Gore. et.al. 1988, done a study to reveal the "Effect of KB on some of the body function" Effect of KB on some of the body functions was studied with the help of channel polygraph system. During KB the HR increased by 15 beats/min., the eye movement were found increased by KB even if the eyes were closed. The alpha activity from the parieto-occipoital one a showed a marginal decrease in 57% observations indication a mind quieting effect on the brain. Peripheral blood circulation as measured by way of finger plethysmography, was also found decreased. This reduction persisted up to 35 to 45 seconds after KB.

Respiratory rate also decreased by 3-5 breath/min immediately after KB.[41]

3.5 KAPALBHATI ON BIOCHEMICAL VARIABLES

Desai BP in 1990 showed that decrease in blood urea, increase in creatinine and tyrosine after one minute of KB. According to biochemical point of view the practice of KB seems to promote decarboxylation and oxidation mechanisms due to which quieting of respiratory centers is achieved.[42]

3.6 KAPALBHATI ON RESPIRATORY SIGNALS

StancákA et al., 1991 Yogic high-frequency respiration was studied with respiratory signals during KB were modulated by frequency of 0.1 Hz and 0.2-0.3 Hz. This frequency component was reduced in R-R intervals but increased in blood pressure during KB as compared to that at rest. The occurrence of both frequency components in respiration during KB shows that integrative role of cardiovascular and respiratory rhythms involvements in physiological states characterized by altered respiratory frequency. [43]

3.7 KAPALBHATI ON BRAIN WAVES

Another study of **Stancák et al., 1991** in eleven advanced yoga practices shows that alpha activity was increased during the initial five min of KB. Theta activity mostly in the occipital region was increased during later stages of 15 min KB. Beta 1 activity increased during the first 10 min of KB in occipital and to a lesser degree in parietal regions. Alpha and beta 1 activity decreased and theta activity was maintained on the level of the initial resting period after KB. The results suggest a

relative increase of slower EEG frequencies and relaxation on a subjective level as the after effect of KB exercise.[44]

3.8KAPALBHATI ON CARDIOVASCULAR SYSTEM

Earlier study of **Stancák et al., 1991** concluded that HR increased by 9 beats per min during KB. Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) increased during KB by 15 and 6 mmHg respectively. All frequency bands of R-R interval variability were reduced in KB. Also the BRS parameter was reduced in KB. The amplitude of the high-frequency oscillations in SBP and DBP increased during KB and also decreased cardiac vagal tone during KB which was due to changes in respiratory pattern and due to decreased sensitivity of arterial baroreflex. Decreased respiratory rate and increased SBP and low-frequency blood pressure oscillations after KB suggest a differentiated pattern of vegetative activation and inhibition associated with KB.[45]

3.9 CARDIO-RESPIRATORY CHANGES DURING THE PRACTICE OF KAPALBHATI

A study was conducted by **Kuna et al. (1991)** on Kapalabhati practice and cardio- respiratory changes.

The results showed that HR increased by nine beats per minute during KB. SBP and DBP increased during KB by 15 and 6 mmHg respectively. All frequency bands of R-R interval variability were reduced in KB.

Also the BRS parameter was reduced in KB. The amplitude of the high-frequency oscillations in SBP and DBP increased during KB. The low-frequency blood pressure oscillations were increased after KB.[46]

3.10 EFFECT OF KAPALBHATI ON AUTONOMIC NERVOUS SYSTEM

A study was conducted by **Kennedy et al. 1993,** on the effects of unilateral forced nostril breathing on the heart. Three experiments were done that employ impedance cardiography to monitor the effects of unilateral forced nostril breathing (UFNB) on the heart. Subjects were selected with the respiratory rate of six breaths per minute (BPM). Experiment two includes 16 trials using one subject to examine the intraindividual variability, at six BPM. Experiment three includes ten trials with the same subject in experiment two. It was found that all three experiments demonstrated that right UFNB increases HR (HR) compared to left.

Experiment one gave seven negative slopes, or lowering in HR with left nostril breathing and seven positive slopes, or increases in HR with right nostril breathing, p =.001.

The second and third experiments showed differences in HR means in which right UFNB increases HR more than left, p = .013, p = .001, respectively. In experiment two stroke volume was higher with left UFNB, p = .045, compensating for lower HR. Left UFNB increased end diastolic volume as measured in both experiments one and two, p = .006, p = .001, respectively.

These results demonstrate a unique unilateral effect on sympathetic stimulation of the heart that may have therapeutic value.[47]

3.11 KAPALBHATI ON CARDIO-RESPIRATORY VARIABLES

Thakur et al.,1995 study done to see the effect of KB on cardio respiratory variables, there was significant increase in vital capacity (f=26.82 against required value of 4.08), resting pulse rate (f=45.23 against required value of 4.08), other side blood pressure and air flow rate showed significant change by practice of KB Kriya.[48]

3.12. KAPALBHATI ON CARDIO-RESPIRATORY ENDURANCE

Abraham et al.,2000 did a study to investigate the comparative effects of Suryabhedna, KB and their combination on cardio-respiratory endurance and selected physiological variables. It was concluded that eight weeks combined practice of KB and Suryabedna is not giving any significant changes in various cardio-respiratory variables of experimental and control groups.[49]

3.13. ADVERSE EFFECT OF KAPALBHATI

In 2004, Johnson reported that a 29-year-old healthy woman

affected by spontaneous pneumothorax caused by a Kapalabhati pranayama. This is the only known report of spontaneous pneumothorax caused by pranayama, but some other rare causes are noted. This case study illustrated that adverse side effects can occur when one pushes the body to physiologic extremes.[50]

3.14. IMMEDIATE EFFECT OF PRANAYAMA ON HAEMODYNAMICS

Study done by **Subbalakshmi et al. on 2005** showed that following nadi-shodhana pranayama practice of 20 minutes, significantly decline in basal HR ($P<0.0001$) and systolic pressure ($P<0.001$). Peak expiratory flow rate was significantly improved ($P<0.01$) and the time taken for simple problem solving was significantly less following pranayama practice ($P<0.0001$). The study suggested that the nadi-shodhana pranayama rapidly alters cardiopulmonary responses and improves simple problem solving.[51]

3.15. KAPALBHATI ON P300 EVENT-RELATED POTENTIALS

A study was done by **Joshi and Telles on 2008**, the effects of kapalabhati and breath awareness on event-related potentials in trained yoga practitioners" The objective of the study was to compare the P300 event-related potentials recorded before and after (1) high-frequency yoga breathing (HFYB) and (2) breath awareness. The P300 was recorded in participants of two groups before and after the intervention session (one minute in duration). The two groups were each given a separate intervention. One group practiced a HFYB at a frequency of approximately 2.0 Hz, called kapalabhati. The other group practiced breath awareness. The P300 event-related potential, which is generated when attending to and discriminating between auditory stimuli, was recorded before and after both techniques. It was found that P300 peak latency decreased after HFYB and the P300

peak amplitude increased after breath awareness. Hence it was concluded that both practices (HFYB and Breath awareness), though very different, influenced the P300. HFYB reduced the peak latency.[52]

3.16. IMMEDIATE HAEMODYNAMIC EFFECT OF BHASTRIKA

Pramanik, T., et al. on 2009, done a study to evaluvate the "Immediate effect of slow pace Bhastrika pranayama on blood pressure and HR.After 6 minutes practice of slow pace bhastrika pranayama thus shows a strong tendency to improving the autonomic nervous system through enhanced activation of the parasympathetic system.[53]

3.17. KAPALBHATI ON PEAK EXPIRATORY FLOW RATE

BalBaljinderet al., 2009 studied on six-week kaphalabhati on peak expiratory flow rate and pulse rate in healthy volunteers the study revealed that increases in the pulmonary functions.[54]

3.18. KAPALBHATI ON BODY COMPOSITION

Study by **Ajay Singh et al., 2010** significant decreases in the body composition for 12 weeks of KB on young adults.[55]

3.19. KAPALBHATI ON RESPIRATORY SYSTEM

Dharmender et al., 2001 conducted a study with a purpose to investigate the comparative effect of Kapalabhati and anulom vilom on selected respiratory variables, analysis of covariance was applied at significance level.[56]

3.20. KAPALBHATI ON ILLUSION

Another study of **Telles S et al., 2011** shows that kaphalabhati and breath awareness may help to decrease in the degree of optical illusion in the experimental group whereas no changes in the control group.[57]

3.21 KAPALBHATI ON MOTOR SKILLS

Telles et al., 2012 done a study to prove that both Kapalabhati and breath awareness can produce improvement in visual discrimination and fine motor skills, with a greater magnitude of change after kapalabhati.[58]

3.22. KAPALBHATI ON BODY MASS INDEX

Dinkar R, 2013 shows that 8 weeks of KB practice on resident doctors found significant changes in the BMI and Skin fold thickness as compared to that of control group.[59]

3.23. KAPALBHATI ON STRESS

Vivek Kumar Sharma, Madanmohan et al., 2013 study was conducted to compare the effects of commonly practiced slow and fast pranayama on perceived stress and cardiovascular functions in young health-care students Kapalabhati, Bhastrika and Kukkuriya Pranayama as fast breathing while Nadishodhana, Savitri and Pranav Paranayama as slow. Pranayama training was given for 30 min, 3 times a week for the duration of 12 weeks after 12 weeks of training; perceived stress scale (PSS), HR

(HR), respiratory rate, systolic blood pressure and diastolic blood pressure (DBP), mean arterial pressure (MAP), rate pressure product (RPP), and double product (Do P). There was a significant decrease in PSS scores in both fast and slow pranayama groups, but percentage decrease was comparable in these groups. Significant decrease in HR, DBP, RPP, and DoP was seen in only slow pranayama group.[60]

3.24. KAPALBHATI ON CARDIORESPIRATOIN

Dinesh T et al., 2013 conducted study on the effect of 12 weeks of Kapalabhati pranayama training on cardiorespiratory parameters in healthy, young subjects.. Initially Kapalabhati pranayama started with 30 times for 1 min and increased to 5 minutes/day, twice daily, thrice/ week for 12 weeks. Study revealed that there is marginal decrease in all basal cardiovascular parameters while RR decreased significantly ($P<0.01$). On the other hand, there was a significant ($P<0.05$) increase in RR in control group.[61]

3.25. KAPALBHATI ON PSYCHOMOTOR SKIL

In 2013, Pradhan B by his study concluded that after short term practice of Kaphalabhati in adults have no significant results on psychomotor performance like six-letter cancellation and digit letter substitution task. Error scores have also increased after performing this breathing technique.[62]

3.26. KAPALBHATI IN SCHIZOPHRENIC PATIENTS

Study done by **Bhargav H et al., 2014** in schizophrenia patients shown have reduced bilateral pre-frontal activation during KB as compared to healthy controls. This hypo-frontality of schizophrenia patients in response to KB may be used clinically to support the diagnosis of schizophrenia in future.[63]

3.27 KAPALBHATI ON METABOLIC FITNESS AND BONE INTEGRITY

Baljinder Singh Bal et al ., 2015, study was conducted with the variables to find the therapeutic effects of KB Pranayama on Metabolic Fitness (MetF) and Bone Integrity (BI). After 4-weeks KB pranayama, significant differences were found in Maximal Oxygen Consumption, Blood Pressure and Blood Sugar, insignificant in Blood Lipid and Bone Integrity.[64]

3.28. KAPALBHATI ON HEMATOLOGY

Baljinder Singh Bal on 2015 conducted a study to determine the short-term effects of KB Pranayama on hematological parameters. 4- weeks practice of KB (KB) pranayama showed no significant differences in Hemoglobin (Hb), Total Cholesterol (TC), Low Density Lipoprotein Cholesterol (LDL-Cholesterol), High Density Lipoprotein Cholesterol (HDL-Cholesterol) and Triglycerides (TG).[65]

3.29. KAPALBHATI ON RESPIRATORY SYSTEM

Baljinder Singh Bal on 2016, done a study on effect KB Pranayama on Respiratory Parameters.4-week practice of KB pranayama, showed that significant improvement in Tidal Volume (VT), Expiratory Reserve Volume (ERV), Vital Capacity (VC) and Inspiratory Capacity (IC).[66]

MATERIALS

AND

METHODS

4.0 MATERIALS AND METHODS

4.1 STUDY DESIGN

4.1.1 TYPE OF THE STUDY

Single group Pre and post Experimental study.

4.2 METHOD

After obtaining informed consent, the selected individuals were subjected to KB training. The training was given by qualified yoga doctors as per standard procedure. Accordingly, the subjects were made to sit in Vajrasana and to forcefully expel all of the air from the lungs while pushing the abdominal diaphragm upwards. The expulsion is active but the inhalation is passive. Subjects rapidly breathed out actively and inhaled passively through both nostrils.

In this study, the KB practice conists of five rounds with fifty strokes of each round in an interval of five deep breathings in between each round. At the end of this kb practice the subjects were made to relax in Savasana for ten minutes.

After obtaining their informed consent the variables (HR, SV, CO) were measured by using non-invasive method of Echocardiogram. There were 3times data collected for an each individual.

The baseline data was collected before the practice of KB and post1 data was taken at the end of KB practice followed by 5 deep breathings, post2 data was taken at the end of 10 minutes relaxation in Savasana.

4.3 ETHICAL CONSIDERATIONS

4.3.1 ETHICAL CLEARANCE

Ethical clearance was sought from the Institutional Ethics Committee prior to the start of the study and the approval for the same was granted.

4.3.2 WRITTEN INFORMED CONSENT

Subjects who fulfilled inclusion criteria were appraised about the purpose of the study and their rights as research subjects. Informed consent form was administered in English.

As all the subjects understood spoke English, there was no requirement of translating the signed informed consent form into native language i.e., Tamil. Adequate time was given to each patient to go through the information sheet and their queries were answered.

Their right to withdraw anytime from the study and the need for willingness to participate voluntarily in the study was explained. All the subjects expressed their willingness to participate in the study by giving a signed informed consent.

(A sample information sheet and consent form is enclosed as Annexure 1

4.4 SUBJECTS

A total of 33 subjects, healthy volunteers of both gender with ages ranging between 18 – 25 years participated in the study

4.4.1 DESCRIPTION OF THE SUBJECTS INCLUDING THE SELECTION OF SAMPLES:

The study subjects were recruited from the Govt. Yoga and Naturopathy Medical College Hospital, Arumbakam , Chennai.

Thirty three healthy subjects between the age group 18 to 25 years are selected for the study from Govt.Yoga and Naturopathy Medical College Hospital, screening is done to assess diagnostic criteria, inclusion and exclusion criteria.

Each of these subjects will undergo a general health checkup to rule out any disease or abnormality.

Each subject was assessed Heart rate, Stroke volume, Cardiac output ,by undergoing Echocardiogram test by single setting.

4.5. INCLUSION AND EXCLUSION CRITERIA

4.5.1 INCLUSION CRITERIA

Age group 18 to 25yrs, Both Genders

4.5.2 EXCLUSION CRITERIA

Participants would be excluded if they have

a. Systemic issue

b. Under medication

c. Chronic illness

d. Regular practice of yoga for the past 3 months

e. Sports person

f. Recently hospitalized

4.6 ASSESSMENTS

The baseline and post-intervention assessments consisted of:

LIST OF OUTCOME VARIABLES:

a) Heart Rate (HR)

b) Stroke Volume (SV)

c) Cardiac output (CO)

4.6.1 METHOD OF DATA COLLECTION

The data of variables (HR, STV, CO) were collected by undergoing Echocardiogram test

4.6.2 ELECTROCARDIOGRAM

An electrocardiogram, or ECG, measures the electrical activity of the heart over a period of time.

It is detected by electrodes attached to the surface of the skin, and recorded by a device external to the body.[27]

4.6.2.1 ECHOCARDIOGRAPHY

Echocardiography refers to the ultrasonic evaluation of cardiac functions. It is a noninvasive technique that does not involve injections or insertion of a catheter. It involves B-Scan ultrasound at a frequency of 2.25MHz using a transducer which also acts as a receiver of the reflected waves. The recording of the echoes displayed against time on an oscilloscope provides a record of:

a) The movement of the ventricular wall and septum and valves during the cardiac cycle.
b) When combined with Doppler techniques, echocardiography can be used to measure velocity and volume of flow through the valves.
c) Thus, it is particularly useful in evaluating end-diastolic volume (EDV),end-systolic volume (ESV),CO and valvular defects.[27]

4.7 INTERVENTION

4.7.1 KAPALABHATI

The subjects were instructed to sit in Vajrasana and to forcefully expel all of the air from the lungs while pushing the abdominal diaphragm upwards. The expulsion is active but the inhalation is passive. Subjects rapidly breathed out actively and inhaled passively through both nostrils. Five rounds of KB, each round consists of fifty strokes with an interval of five deep breathings in between each round. At end of 5 deep breathing, subjects were instructed to relax in Savasana for 10 mints.

4.8 COLLECTION OF DATA

The baseline data was collected before the practice of KB and post1 data was taken at the end of KB practice followed by 5 deep breathings, post2 data was taken at the end of 10 minutes relaxation in Savasana.

4.9 DATA EXTRACTION & ANALYSIS

4.9.1 DATA EXTRACTION:

The data was collected as self-reported observations using outcomes variables. The

assessments were done before the practice (baseline data), immediately after the practice of KB (post 1), after 10 minutes relaxation in Savasana (post 2). The data was organized in Microsoft Excel Sheets (Version 2007).

4.9.2 DATA ANALYSIS:

The descriptive statistics means (SD) for normally distributed variables, median (interquartile range) for skewed variables and n (%) for categorical variables were reported. Based on the normality check of the data, non- parametric Wilcoxon-Signed Rank test was applied to the data. The graphical technique of Histogram and also the Shaprio-Wilk test were used for HR, Stroke volume and Cardiac output parameters to see change over the time points. All test were two-sided at α=0.05 level of significance. All analyses was done using Statistical Package for social services (SPSS) software version 21.0 (Armonk, NY:IBM Corp).

RESULTS

5.0 RESULTS

DEMOGRAPHICS TABLE -

Demographic and other characteristics of participants

Parameter	Statistics (N=33)
Age (years)	18.8 ± 1.2
Gender	
Female	22 (66.7)
Male	11 (33.3)
Baseline Heart Rate (bpm)	73.6 ± 11.9
Post 1 Heart Rate (bpm)	72.2 ± 12.4
Post 2 Heart Rate (bpm)	69.7 ± 12.3
Baseline Stroke Volume (ml)	54.7 ± 12.9
Post 1 Stroke Volume (ml)	55.9 ± 14.9
Post 2 Stroke Volume (ml)	60.8 ± 15.3
Baseline Cardiac Output (ml)	3953.3 ± 948.2
Post 1 Cardiac Output (ml)	4007.0 ± 1161.8
Post 2 Cardiac Output (ml)	4294.2 ± 1485.1
Values are presented as Mean ± SD, categorical data presented as n (%).	

TABLE 2: Analysis of change from baseline to post 1time point measurement for the following parameters

Parameter	Visits	Statistics		p-value *
		n	Median (IQR)	
Heart Rate (bpm)	Baseline	33	76.0 (64.0 , 82.0)	0.24
	Post 1	33	70.0 (66.0 , 78.0)	
	Change from baseline to Post 1 time point	33	2.0 (-3.5 , 8.5)	
Stroke Volume (ml)	Baseline	33	52.0 (45.5 , 64.5)	0.64
	Post 1	33	55.0 (44.4 , 68.1)	
	Change from baseline to Post 1 time point	33	1.0 (-10.3 , 7.9)	
Cardiac Output (ml)	Baseline	32	3922.0 (3475.5 , 4252.5)	0.70
	Post 1	33	3930.2 (3098.5 , 4985.6)	
	Change from baseline to Post 1 time point	32	-150.0 (-817.3 , 906.9)	

IQR is given as (25 th percentile , 75 th percentile)

* p- value is obtained from Non- Parametric Wilcoxon-Signed Rank Test

Interpretation:

There is no enough evidence to show that there is statistically significant change from the baseline to post 1 measurements for the following parameters “Heart rate (bpm), Stroke Volume (ml) and Cardiac Output (ml). P values are not statistically significant.

TABLE 3: Analysis of change from baseline to post 2 time point measurement for the following parameters

Parameter	Visits	Statistics		p-value *
		n	Median (IQR)	
Heart Rate (bpm)	Baseline	33	76.0 (64.0 , 82.0)	0.015
	Post 2	33	68.0 (62.0 , 76.0)	
	Change from baseline to Post 2 time point	33	4.0 (-1.5 , 11.5)	
Stroke Volume (ml)	Baseline	33	52.00 (45.5 , 64.5)	0.032
	Post 2	33	60.40 (46.2 , 68.6)	
	Change from baseline to Post 2 time point	33	-2.8 (-19.9 , 3.7)	
Cardiac Output (ml)	Baseline	32	3922.0 (3475.5 , 4252.5)	0.33
	Post 2	33	3964.4 (2856.3 , 5690.4)	
	Change from baseline to Post 2 time point	32	-184.0 (-1111.7 , 557.9)	
IQR is given as (25 th percentile , 75 th percentile)				
* p- value is obtained from Non- Parametric Wilcoxon-Signed Rank Test				

INTERPRETATION:

HEART RATE AND STROKE VOLUME:

There is an evidence to show that statistically significant change from the baseline to post 2 measurements for the above mentioned parameters ($p = 0.02; 0.03$).

CARDIAC OUTPUT:

There is no enough evidence to show that there is statistically significant change from the baseline to post 2 measurements and p value is not statistically significant.

TABLE 4: Analysis of change from Post 1 to Post 2 time point measurement for the following parameters

Parameter	Visits	Statistics		p-value *
		n	Mean (SD)	
Heart Rate (bpm)	Post 1	33	72.1 (12.4)	0.211
	Post 2	33	69.7 (12.3)	
	Change from Post 1 to Post 2 time point	33	2.5 (11.1)	
Stroke Volume (ml)	Post 1	33	55.9 (14.9)	0.172
	Post 2	33	60.8 (15.3)	
	Change from Post 1 to Post 2 time point	33	-4.9 (20.1)	
Cardiac Output (ml)	Post 1	32	4007.0 (1161.7)	0.373
	Post 2	33	4294.2 (1485.1)	
	Change from Post 1 to Post 2 time point	33	-287.2 (1825.6)	
* p- value is obtained from Parametric Paired t test				

INTERPRETATION:

There is no enough evidence to show that there is statistically significant change from the post 1 to post 2 measurements for the following parameters “Heart rate (bpm), Stroke Volume (ml) and Cardiac Output (ml). P values are not statistically significant.

TABLE5: Analysis of change over the visits for the following parameters using Manova test

Parameter	Visits	Statistics				p-value *
		n	Mean	SD	95% CI	
Heart Rate (bpm)	Baseline	33	73.6	11.9	(69.3 , 77.8)	0.045
	Post 1	33	72.1	12.3	(67.7 , 76.5)	
	Post 2	33	69.7	12.2	(65.3 , 74.0)	
Stroke Volume (ml)	Baseline	33	54.7	12.9	(50.1 , 59.3)	0.024
	Post 1	33	55.8	14.9	(50.5 , 61.1)	
	Post 2	33	60.7	15.3	(55.3 , 66.1)	
Cardiac Output (ml)	Baseline	32	3953.3	948.1	(3611.4 , 4295.1)	0.23
	Post 1	32	3969.7	1160.1	(3551.4 , 4387.9)	
	Post 2	32	4306.8	1507.0	(3763.4 , 4850.1)	
SD – Standard Deviation ; 95% CI – 95 % Confidence Interval * p-value is obtained from MANOVA Test						

INTERPRETATION:

HEART RATE AND STROKE VOLUME:

There is an evidence to show that statistically significant change over the time points for the above mentioned parameters (p = 0.04; 0.02).

CARDIAC OUTPUT:

There is no enough evidence to show that there is statistically significant change over the time points and p value (0.23) is not statistically significant.

FIGURE 21: Heart rate change over the visits

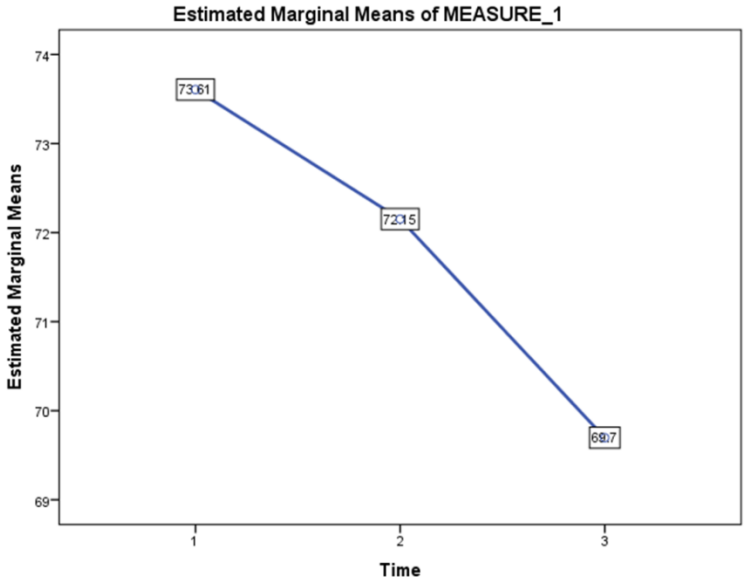


FIGURE 22: Stroke volume change over the visits

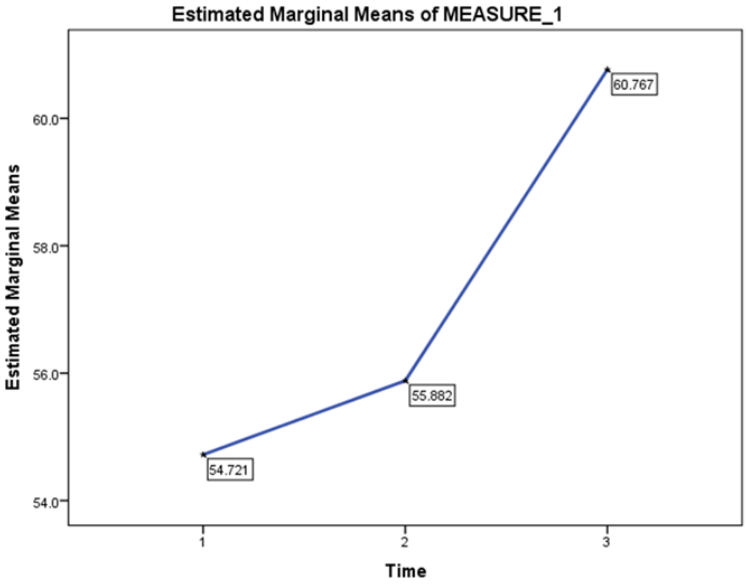


FIGURE 23: Cardiac output change over the visits

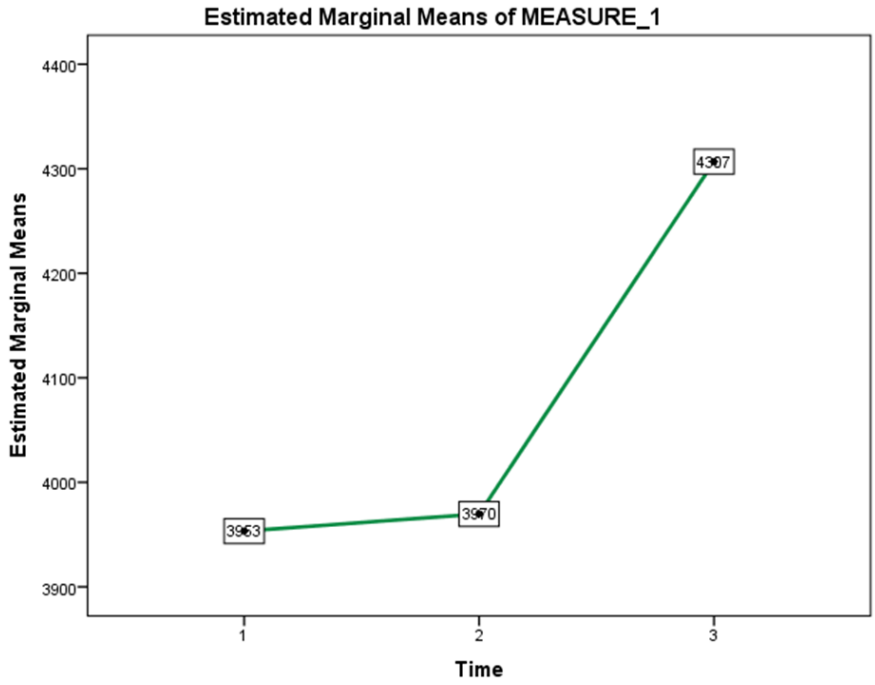
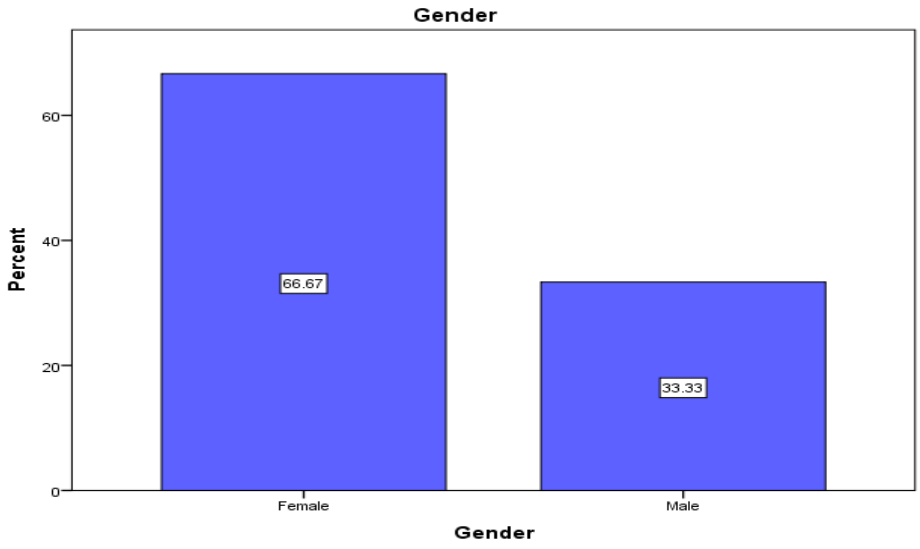


FIGURE 24: Gender



DISCUSSION

6.0 DISCUSSION

The present study was conducted to evaluate whether the practice of KB had any influence on immediate hemodynamic changes of CO.

The results showed that there is no enough evidence to show that statistically significant changes immediately after the practice of KB in Cardio dynamic parameters of Heart rate (HR) , Stroke volume (SV) and Cardiac output (CO).

There is no enough evidence to show that there is statistically significant change from the post 1 to post 2 measurements for the following parameters "Heart rate (bpm), Stroke Volume (ml) and Cardiac Output (ml). P values are not statistically significant.

There is enough evidence to show that statistically significant changes in Cardio dynamic parameters of Heart rate (HR) , Stroke volume (SV) and Cardiac output (CO) after 10 minutes relaxation in Savasana at the end of practice of KB.

The result of this study revealed that there is no change in the HR and stroke volume immediately after the practice of KB, but there is significant change from the baseline when the subjects were exposed to Savasana for ten minutes after the practice of KB. The present study reveals improved cardiovascular autonomic reactivity, i.e. increase in the parasympathetic and decrease in sympathetic activity with the practice of KB followed by 10 minutes relaxation in Savasana.

This shows that there is a dominance of parasympathetic activity and suppression of sympathetic activity. Similar results were found in another study. Very few references

are available on the effect of practicing fast pranayamas on the autonomic functions in individuals.

One more study reported that practice of kapalbhati alone reduces sympathetic activity similar to the present study.[74]

In another study, when[77] different pranayama's were done in a set of different groups consisting of slow breathing, fast breathing and simple breath awareness, it concluded that slow breathing had a better effect than fast breathing but it also showed that variables like blood pressure (BP) decreased in both types of breathing unlike other variables which showed significant changes only in slow breathing.

A study[43] done on advanced yoga practitioners evaluating cardiovascular and respiratory changes using a yogic breathing exercise Kapalabhati (KB) revealed that the practice of KB gave rise to an increase in sympathetic arousal in the form of decreased R-R intervals and increased in Systolic and Diastolic blood Pressure. Similar, changes have been seen in this study which showed an increase in sympathetic stimulation upon during the practice of KB.

In another study done by Jain (2016), 6 weeks practice of Kapalabhati with significant reduction in heart rate and systemic peripheral resistance. This indicates that Kapalabhati practice increases the sympathetic tone only during the practice, but final after effect of KB is reduced sympathetic tone or increase in vagal tone.[75] This finding very well supports this study which shows its reductions in HR and systemic

peripheral resistance upon performing 6 weeks of KB, which adds more strength to this study.

During extended voluntary expiration, there is raise of intra-thoracic pressure causing more blood flow to the heart from lung and thus increasing the stroke volume. This in turn increases the blood pressure stimulating the baroreceptors in carotid sinus.[76]

Further, this increased baroreceptor discharge inhibits the vasoconstrictor nerves and excites the vagus innervations of the heart. Decrease in HR indicates a decrease in sympathetic activity and / or increase in parasympathetic activity.

Results of this study are in agreement with that of Raghu raj et al in 1998 found practicing fast pranayama like Kapalabhati for 12 weeks lead to decrease in sympathetic activity and are not in agrement with observations of few other studies.

Madanmohan et al in 2005 evaluated short term effect of three weeks of fast pranayama (bhastrika) practice on cardiorespiratory variables and reported an increase in sympathetic activity whereas Pal et al in 2004 found no change in autonomic activity by the practice of 12 weeks of Kapalabhati pranayama .[74'78]

Another study conducted by Kullok et al in 1990 explained changes in autonomic activity by breathing exercises on the basis. Of known anatomical asymmetries in the respiratory, cardiovascular and nervous system and that the coupling mechanisms between each of these systems: lung, heart, heart-brain and lungs-brain are also asymmetrical. [79]

These are the possible reasons supporting this study of drop in heartrate .

According to Frank-Starling mechanism of the heart that the greater the heart muscle is stretched during filling, the greater is the force of contraction and the greater the quantity of blood pumped into the aorta. In this study the stroke volume increased because of increased venous return. When an extra amount of blood flows into the ventricles, the cardiac muscle itself is stretched to greater length. This cardiac muscle stretch creates a change in the arterial blood pressure. High receptor zones in the aortic and carotid sinuses detect changes in the arterial blood pressure that stimulates the Baroreceptors to send signals to medulla of brain stem which immediately

adjust the Mean Arterial Blood Pressure and altering both force and speed of heart muscle contractions and reduces heart rate.[23]

An another possible reason for the reduction in heart rate must be Nasocardiac reflex. Increased pressure in the nasal mucosa , stimulates mechanoreceptors of nasal mucosa the afferent fibers are carried through Trigeminal nerve to the NTS. Stimulation of vagal nerve by Nucleus ambigus controls both force and speed of heart muscle contractions and reduces heart rate.[73]

In further, this study substantiates the claim that Kapalabhati pranayama practice is beneficial on cardio-vascular function in healthy volunteers.

Reduction in HR is advantageous for HR increased conditions like Anemia, Hypoxia, Hyperthyroidism, hyper secretion of catecholamines, Cardiomyopathy, Diseases of

heart valves. Yet the cardiac output remains the same in spite of increasing the HR so this may be useful to improve Cardiovascular diseases.

Therefore, KB practice may be a useful tool to keep the person healthy throughout the life if it is practiced regularly as the beneficial effects of Kapalabhati pranayama are encouraging.

6.1DIRECTIONS FOR FUTURE RESEARCH

a. This study should be replicated with a larger sample size.

b. A study should be conducted with any cardiovascular dieases individual with longer duration would have bene better.

CONCLUSION

7.0 CONCLUSION

The present study was conducted to evaluate whether the practice of KB had any influence on immediate hemodynamic changes of CO.

The results showed that there is no enough evidence to show that statistically significant changes immediately after the practice of KB in Cardio dynamic parameters of Heart rate (HR) , Stroke volume (SV) and Cardiac output (CO).

There is enough evidence to show that statistically significant changes in Cardio dynamic parameters of Heart rate (HR) , Stroke volume (SV) and Cardiac output (CO) after 10 minutes relaxation in Savasana at the end of practice of KB.

There is no enough evidence to show that there is statistically significant change from the post 1 to post 2 measurements for the following parameters “Heart rate (bpm), Stroke Volume (ml) and Cardiac Output (ml). P values are not statistically significant.

SUMMARY

8.0 SUMMARY

Cardiovascular disease is the leading cause of death for both men and women.[67] Lifestyle modifications are most important factors in the treatment, prevention, and rehabilitation of cardiovascular disorders.[68]

Yoga is one of the best lifestyle modifications and an ancient vedic science thought to have originated in India in 5000 BC which is being applied in the field of therapeutics.[69,70]

It includes practice of specific posture (āsana), regulated breathing (Prāṇāyāma) etc., Breath is the dynamic bridge between body and mind and Prāṇāyāma is one of the most important yogic practices.[71]

The aim of this study was to evaluate the effect of immediate haemodynamic changes of kapalabhati pranayama on healthy volunteers.

Pranayama involves manipulation of breath movement and the breath is a dynamic bridge between the body and mind. KB improves vagal tone.

In this study, the subjects recruited from the Out-patient department of Government Yoga and Naturopathy Medical College Hospital, Arumbakkam, Chennai.

After obtaining informed consent, the selected individuals were subjected to KB training. The training was given by qualified yoga doctors as per standard procedure. Accordingly, the subjects were made to sit in Vajrasana and to forcefully expel all of the air from the lungs while pushing the abdominal diaphragm upwards. The

expulsion is active but the inhalation is passive. Subjects rapidly breathed out actively and inhaled passively through both nostrils.

In this study, the KB practice conists of five rounds with fifty strokes of each round in an interval of five deep breathings in between each round. At the end of this kb practice the subjects were made to relax in Savasana for ten minutes.

After obtaining their informed consent the variables (HR, SV, CO) were measured by using non-invasive method of Echocardiogram. There were 3times data collected for an each individual in a single setting..

The baseline data was collected before the practice of KB and post1 data was taken at the end of KB practice followed by 5 deep breathings, post2 data was taken at the end of 10 minutes relaxation in Savasana.

The present study was conducted to evaluate whether the practice of KB had any influence on immediate hemodynamic changes of CO.

The results showed that there is no enough evidence to show that statistically significant changes immediately after the practice of KB in Cardio dynamic parameters of Heart rate (HR) , Stroke volume (SV) and Cardiac output (CO).

There is no enough evidence to show that there is statistically significant change from the post 1 to post 2 measurements of Cardio dynamic parameters of Heart rate (HR) , Stroke volume (SV) and Cardiac output (CO).

There is enough evidence to show that statistically significant changes in Cardio dynamic parameters of Heart rate (HR) , Stroke volume (SV) and Cardiac output (CO) after 10 minutes relaxation in Savasana at the end of practice of KB.

This shows that there is a dominance of parasympathetic activity and suppression of sympathetic activity. Similar results were found in another study. Very few references are available on the effect of practicing fast pranayamas on the autonomic functions in individuals. One more study reported that practice of kapalbhati alone reduces sympathetic activity similar to the present study.

Further our study substantiates the claim that reduction in HR is advantageous for HR increased conditions like Anemia, Hypoxia, Hyperthyroidism, hyper secretion of catecholamines, cardiomyopathy, diseases of heart valves. yet the cardiac output remains the same in spite of increasing the HR so this may be useful to improve cardiovascular diseases.

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9.0 BIBLIOGRAPHIC REFERENCES

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ANNEXURES

10.0 ANNEXURES

ANNEXURE 1: CONSENT FORM

INFORMED CONSENT FORM

Title of the study: “Effect of immediate hemodynamic changes of kapalbhati on healthy volunteers”

Name of the Participant:

Name of the Principal Investigator: Dr. M. Malathi

Name of the Institution:

Government Yoga and Naturopathy Medical College Hospital, Arumbakkam, Chennai – 600 106

Documentation of the informed consent

I _____ have read the information in this form (or it has been read to me). I was free to ask any questions and they have been answered. I am over 18 years of age and, exercising my free power of choice, hereby give my consent to be included as a participant in the study of “Effect of immediate hemodynamic changes of kapalbhati on healthy volunteers”

1. I have read and understood this consent form and the information provided to me.
2. I have had the consent document explained to me.
3. I have been explained about the nature of the study.
4. I have been explained about my rights and responsibilities by the investigator.
5. I have been informed the investigator of all the treatments I am taking or have taken in the past _____ months including any native (alternative) treatment.
6. I have been advised about the risks associated with my participation in this study.

7. I agree to cooperate with the investigator and I will inform him/her immediately if I suffer unusual symptoms.

8. I have not participated in any research study within the past _____month(s).

9. I am aware of the fact that I can opt out of the study at any time without having to give any reason and this will not affect my future treatment in this hospital.

10. I am also aware that the investigator may terminate my participation in the study at any time, for any reason, without my consent.

11. I hereby give permission to the investigators to release the information obtained from me as result of participation in this study to the sponsors, regulatory authorities, Govt. agencies, and IEC. I understand that they are publicly presented.

INFORMATION SHEET

We are conducting a study "Effect of Immediate hemodynamic changes of Kapalbhati on healthy volunteers" at Government yoga and naturopathy medical college hospital, Chennai.

The purpose of this study is to evaluate the effectiveness of kapalbhati on immediate hemodyunamicchanges.Here we use Echocardiogram non- invasive method to find the

exact heart rate,strokevolume,cardiacoutput,before and after the practice of kapalbhati.

The privacy of the patients in the research will be maintained throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

Taking part in this study is voluntary.

You are free to decide whether to participate in this study or to withdraw at any time; your decision will not result in any loss of Benefit to which you are otherwise entitled.The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Signature of investigator Signature of participant

Date:

ANNEXURE 2:

SOCIO DEMOGRAPHIC DATA SHEET

1. ID. No: 2. R. No:

2. Age: 4. Date:

3. Sex: 6. Religion:

7. Educational status: 8. Occupation:

9. Monthly income: 10. Marital status:

11. Languages known:

12. Postal address:

a. Landline :

b. Mobile :

c. Em

ANNEXURE 3: RAW DATA

Cardiac Variables (RAW DATA)

S.no.	Names	Age/Sex	HR/bpm			SV/ml			CO/ml		
			Pre	Post_1	Post_2	Pre	Post_1	Post_2	Pre	Post_1	Post_2
1	Monisha	19/F	64	67	60	54	67	54	3456	4489	3240
2	Jayasakthi	19/F	73	64	74	36	20	38	2628	1280	2812
3	Deepika	19/F	78	71	62	46	55	45	3588	3905	2790
4	Sathish	19/F	79	66	68	50	49	58	3950	3234	3944
5	Vasanth	19/F	57	72	54	48	80	41	2736	5760	2214
6	Madhesh	18/M	82	78	68	48	38.2	69.4	3936	2979.6	4719.2
7	Santhosh	18/m	84	68	72	56.7	44.1	83.6	4762.8	2998.8	6019.2
8	Vivek	18/m	82	86	78	46.1	45.7	61.8	3780.2	3930.2	4820.4
9	Madhesh	19/m	92	94	94	42.6	49.8	61.8	3919.2	4681.2	5809.2
10	Karthik	18/m	76	94	71	76.4	54.4	69	5806.4	5113.6	4899
11	Parthasara	19/m	96	93	83	55.4	51.3	68.3	5318.4	4770.9	5668.9
12	Karthik	18/m	56	46	73	76.2	67	98.8	4267.2	3082	7212.4
13	Vignesh	18/m	76	73	67	65	75.3	60.8	4940	5496.9	4073.6
14	Mahendra	18/m	51	58	46	71.7	64.8	58.3	3656.7	3758.4	2681.8
15	Umarani	21/F	64	67	63	35.1	40.8	41.4	2246.4	2733.6	2608.2
16	Alkousar	19/f	79	77	85	77.3	70.5	67.2	6106.7	5428.5	5712
17	Varsha	18/F	78	76	84	74.4	68.3	60.2	5803.2	5190.8	5056.8
18	Zheeja	18/F	84	78	66	50.1	42.4	74.8	4208.4	3307.2	4936.8
19	Sangamith	18/F	88	92	96	44.6	52.8	66.2	3924.8	4857.6	6355.2
20	Nivetha	18/F	74	70	64	64	74.3	60.8		5201	3891.2
21	Gowri	18/F	54	44	70	76.2	68	96.8	4114.8	2992	6776
22	Praveen	19/M	78	66	68	52.4	48.1	58.3	4087.2	3174.6	3964.4
23	Prakashra	19/M	82	84	78	48.3	44.4	60.4	3960.6	3729.6	4711.2
24	Poornima	18/F	76	72	62	48	57	46.1	3648	4104	2858.2
25	Lekhashre	18/F	68	66	64	37.5	42.4	44.6	2550	2798.4	2854.4
26	Soniya	18/F	84	70	72	58.6	44.5	84.8	4922.4	3115	6105.6
27	Dhivya	18/F	64	66	62	56.8	68.3	54.2	3635.2	4507.8	3360.4
28	Muthulaks	18/F	52	60	48	74.7	67.5	62.3	3884.4	4050	2990.4
29	Gulsan	18/F	72	63	74	37	26.4	39.8	2664	1663.2	2945.2
30	Madhumit	18/F	60	75	58	52	82.4	44.2	3120	6180	2563.6
31	Agilanadh	22/F	62	67	60	57	71.2	57.1	3534	4770.4	3426
32	Keerthan	22/F	90	92	96	44.6	56.8	72	4014	5225.6	6912
33	Azhagusar	22/F	74	66	60	45.1	56.4	46.3	3337.4	3722.4	2778